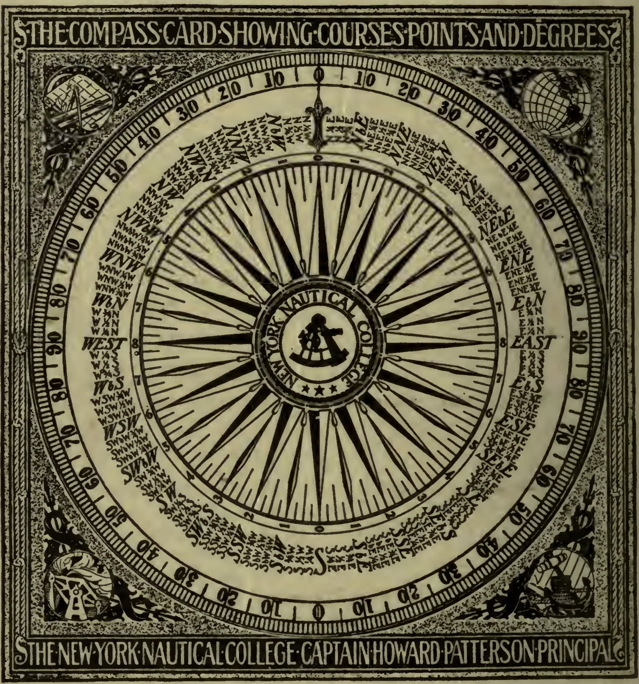
THE NAVIGATOR'S POCKET-BOOK

CAPTAIN HOWARD PATTERSON

No. 2 No. 1


THE COMPASS CARD SHOWING COURSES POINTS AND DEGREES
NEW YORK NAUTICAL COLLEGE
WEST
EAST
THE NEW YORK NAUTICAL COLLEGE CAPTAIN HOWARD PATTERSON PRINCIPAL

RULES.

To Convert a Correct Magnetic into a Compass Course.

ALLOW Westerly Deviation around the Compass in the direction indicated by Hand No. 2.

ALLOW Easterly Deviation around the Compass in the direction indicated by Hand No. 1.

To Convert a True Course into a Compass Course.

ALLOW Westerly Variation and Westerly Deviation around the Compass in the Direction indicated by Hand No. 2.

ALLOW Easterly Variation and Easterly Deviation around the Compass in the Direction indicated by Hand No. 1.

To Convert a Compass Course into a True Course.

ALLOW Leeway made on the Starboard Tack, also Westerly Variation and Westerly Deviation, around the Compass in the direction indicated by Hand No. 1.

ALLOW Leeway made on the Port Tack, also Easterly Variation and Easterly Deviation, around the Compass in the Direction indicated by Hand No. 2.

To Allow for Deviation when Working Cross Bearings.

TO CONVERT a Compass Bearing into a Correct Magnetic Bearing, allow Westerly Deviation around the Compass in the Direction indicated by Hand No. 1.

TO CONVERT a Compass Bearing into a Correct Magnetic Bearing, allow Easterly Deviation around the Compass in the Direction indicated by Hand No. 2.

Note. *Deviation is always selected from the deviation card for the direction of the ship's head at the time the bearings were taken, and not for the bearings themselves.*

To Determine Deviation by Terrestrial Range.

REFER to the compass card the correct magnetic range bearing as given by chart compass, also the bearing of the range as given by the ship's compass, and if they agree it proves that deviation is absent on the course headed at the time of bearing; but if the correct magnetic range is on the *left hand* of the other then the deviation is *westerly*, and if on the *right hand* it is *easterly.*

To Determine Deviation by Pole Star Bearings.

OBSERVE on the chart the line of compass variation passing through the ship's position, then according to this, mark on the card diagram how the Pole Star should bear by the ship's compass if deviation did not exist. Next take a bearing of the Star by the ship's compass, and refer this bearing to the card. Then if there is no difference between the two points, it may be understood that deviation is absent for the ship's head; but if the compass bearing of the Star is to the *left hand* of the other, the deviation is *easterly*, and if the compass bearing is to the *right hand* it is *westerly.*

Solving Compass Problems by the Revolving Card.

IN WORKING OUT compass problems by the revolving card, the navigator may consider the underneath card as true, or as correct magnetic, and the top card as the ship's compass, etc., then by turning the north point of the top card to the right or to the left of the north point of the under card, as called for, a graphic solution of the problem will be shown.

THE

NAVIGATOR'S POCKET-BOOK

THE
NAVIGATOR'S POCKET-BOOK

ARRANGED FOR IMMEDIATE REFERENCE TO ANY NAVIGATION SUBJECT

A Complete Guide and Instructor for the Navigator, containing Four Hundred Adequate Definitions in Addition to all the Practical Rules for Working Middle Latitude, Mercator's and Great Circle Sailings, as well as Finding the Ship's Place by Numerous Chart Considerations, and the Latitude and Longitude by Dead Reckoning, and by the Sun, Moon, Planets, and Stars

ACCORDING TO SHORT, SIMPLE, AND RELIABLE METHODS

Also the Arithmetic of Angular and Time Measure
Compass Deviation, Nautical Astronomy
Treatise on the Instruments of Navigation
Law of Storms, Keeping the Log Book
Magnetism, Logarithms, Measuring Altitudes
Sumner's Method, Time, Weather, etc., etc.

TOGETHER WITH DANGER-ANGLE AND OTHER TABLES

BY

CAPTAIN HOWARD PATTERSON

Formerly U. S. Navy; Commander of the New York Schoolship "St. Mary's," and Admiral of the Haytien Navy

AUTHOR OF

"*Patterson's Illustrated Nautical Encyclopedia,*" "*Handbook for Masters and Mates,*" "*Patterson's Yachting Series,*" etc.

NEW YORK
CHARLES SCRIBNER'S SONS
1917

To

CHESTER W. CHAPIN, ESQ.

CORINTHIAN YACHTSMAN

Steady at the helm from whatever quarter comes the wind
Quick to catch either the caressing or threatening whisperings of the sea
And novice in nothing that makes a sailor of the highest and truest American type

THIS BOOK IS RESPECTFULLY DEDICATED

BY HIS FRIEND

THE AUTHOR

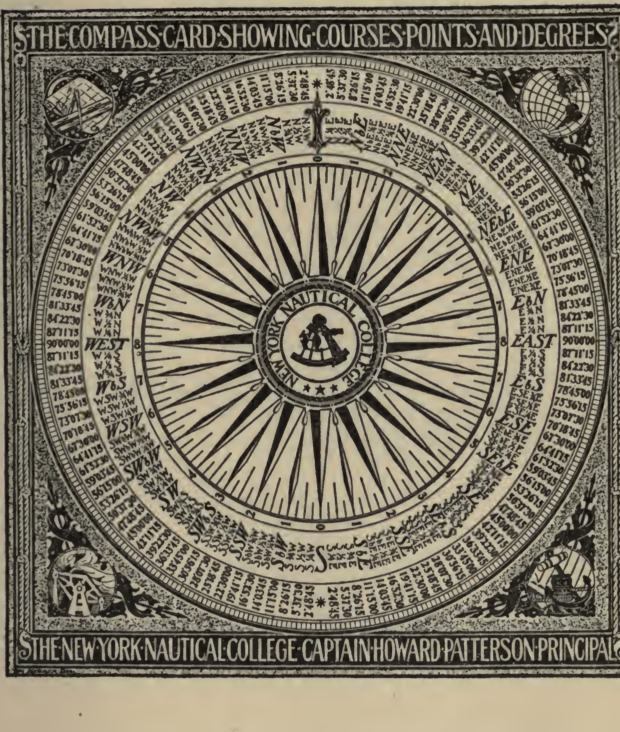
PREFACE

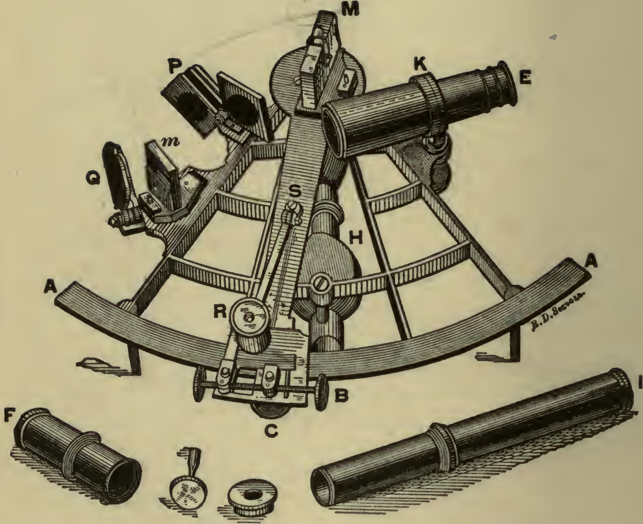
THERE are many voluminous and bewildering works on the subject of navigation, but up to the present time there has not existed a series of short, simple laws founded on correct principles and expressed in homely language, whereby the navigator might quickly develop his position under various conditions at sea and along shore. In this little volume has been incorporated every practical formula for determining the latitude and longitude by dead reckoning and by solar, lunar, and stellar observations, as well as concise and lucid directions for chart-work, the various sailings, and for accurately fixing the ship's place when in sight of land, and in every consideration the author has succeeded in simplifying and abridging the confusing and tedious rules and methods in common use. The purely original arrangement of this pocket edition of common-sense navigation contributes generously to its value, as it affords means of immediate recourse to any and every subject within the sphere of the practical navigator. The problems are all worked according to Bowditch's American Nautical Tables, which may be purchased from any book-dealer for $1.25, but it is to be explained that the numbers called for in the text may be

changed to apply to other navigation tables. In no particular has it been attempted to go beyond the limits of honest, serviceable navigation as practised at sea, consequently the reader would seek in vain for fancy or abstruse sailings and irrelevant definitions.

H. P.

NEW YORK, 1894.


THE COMPASS CARD SHOWING COURSES POINTS AND DEGREES
NEW YORK NAUTICAL COLLEGE
THE NEW YORK NAUTICAL COLLEGE CAPTAIN HOWARD PATTERSON PRINCIPAL



FOR EXPLANATION OF PARTS SEE "SEXTANT."

THE NAVIGATOR'S POCKET-BOOK

A. M.—Ante Meridiem; before meridian; embraces the twelve hours from midnight to noon.

ABOVE THE POLE.—When the north star is situated so that it is intercepted between the observer and the pole, it is said to be above the pole. This applies to other circumpolar bodies. (See Upper Transit.)

ADJUSTING SCREWS.—(See Sextant.)

ADJUSTMENT.—The correction of a compass for deviation by the employment of magnets, or the regulation of the mirrors of a sextant. (See Compass Adjusting; Sextant.)

ALIDADE.—An instrument for taking bearings, consisting of two arms revolving around a circular brass plate or dial marked with the points and degrees of the compass. It is secured on top of the binnacle hood and set to the ship's course, so that any bearing given by it will represent the magnetic bearing as by the compass beneath. (See Azimuth Attachment; Pelorus.)

ALMANAC.—A nautical calendar in which is tabulated for the various days of the month, the declinations of the sun, moon, planets and stars; their right ascensions; the equation of time, etc.

ALTITUDE.—The angular height of a body above the horizon.

Remarks Concerning Meridian Altitudes.—The term meridian altitude means the highest point attained by a heavenly body above the observer's horizon, which is secured when the object bears either true north or south as the case may be. When the observer is north of the body's declination it will be observed to the south, but when the observer is south of the body's declination its image will be thrown to the northern horizon.

By mentally adding four minutes of time to the face of the ship's clock for every degree of longitude sailed east since the clock was last set, or subtracting four minutes for every degree sailed west, the observer will be enabled to anticipate the time of the meridian passage and be prepared to observe the same.

There are two methods employed for bringing the image of a heavenly body to the horizon at the time of the meridian passage, the first of which is as follows :

Make the vernier and arc zeros cut one another, then, in the case of the sun, turn down the shade-glasses to suit the eye ; point the telescope toward the body so that its colored image is seen in the horizon-glass ; now advance the sliding limb, and in proportion as it is moved along the arc, bring the sextant to the vertical—otherwise the image would disappear from the horizon-glass.

The second method practised oftentimes at sea for the meridian observation is to anticipate the approximate altitude and to set the same on the sextant, then to direct the telescope to that part of the horizon which is beneath the body, making a perfect contact by the aid of the tangent screw. This latter method obviates the necessity of "shooting the heavens" and

insures against blinding from the dazzling effects of the sun when caught in the unsilvered part of the horizon-glass. To calculate the approximate altitude, proceed as follows:

When the latitude by dead-reckoning and the declination of the body are of the same name, subtract them from one another, then subtract the remainder from 90°—the answer will be the approximate altitude.

When the latitude by dead-reckoning and the declination of the body are of contrary names, add them together, then subtract their sum from 90°—the answer will be the approximate altitude.

A meridian altitude will always be some part of 90°—an arc from the horizon to the point directly over the head of the observer, called the zenith. This arc is always a quadrant (90°), and what an altitude lacks of 90° is always the zenith distance.

Meridian Altitude of the Sun.—Considering that the sun's image has been brought almost in contact with the horizon, proceed to make a perfect contact by the aid of the tangent screw, fingering the same until the sun's lower limb is just kissing the horizon line. The vertical movement of this luminary is very slow when approaching the meridian, and within several minutes of noon on each side of that point its motion is imperceptible. Until, however, the body is almost on the observer's meridian its limb will show a slow but steady lifting above the horizon, and must be brought down when it shows daylight between it and that part of the horizon which is directly beneath. The idea is to secure the highest altitude which the sun offers.

In order to be positive of the proper place of contact, the navigator should oscillate (swing) the instrument while keeping the eye to the telescope, so that the sun's image will appear to describe the lower segment of a circle, the lowest point of

which will be the horizon directly beneath the sun, ana to which point the limb of the sun must be brought in contact.

As soon as it is decided that the sun is done rising, call "eight bells!" The hands of the ship's clock will then be set at twelve, as the apparent or sun time at the ship. Although twelve o'clock has been "made" at ship, do not consider the observation finished until the image of the sun's limb is seen to dip below the horizon line; but when this is observed, under no circumstances bring the sun's limb up to the line of the horizon, as the dipping of the limb proves that the body has crossed over the highest point of the great circle which it describes from rising to setting; and it is from this highest altitude that we must calculate the ship's distance from the equator by the application of the declination.

In relation to the use of the upper and lower limbs of the sun when observing its altitude, it will be found that the lower limb will afford the most satisfactory result, as a daylight line may be distinguished between it and the horizon; whereas the sinking of the upper limb to the horizon is attended with danger of inaccuracy. (See Latitude.)

Ex. Meridian Altitude of the Sun.—This altitude is measured by simply bringing the sun's image down to that part of the horizon line that is directly beneath the body, proving the point of contact by the oscillation of the sextant. Without further consideration or delay the measured altitude is accepted and read.

Time Altitude of the Sun.—When observing an altitude of the sun for finding the longitude by a chronometer sight or by equal altitudes, simply throw the sun's image to that part of the horizon which is directly beneath the body, proving the point of contact by oscillating the sextant, and at the instant of proper contact note the Greenwich hour, minute, and second shown

by the chronometer. This may be done by having some one stationed by the time-piece, who will make a memorandum of the time when so directed by the navigator calling "time" when he brings the sun's limb in perfect contact, or it may also be done by the navigator himself having a hack watch set to Greenwich time which he holds in the hollow of his left hand, with its face toward him, so that it is in plain view while measuring the altitude. (See Longitude.)

Altitudes in Foggy Weather.—When, owing to light fog or mist, the radius of the visible horizon is only two or three miles, get the eye as near to the surface of the water as possible when measuring the altitude of a heavenly body, and by this means the horizon may often be brought within the fog-described circle. Should the fog be heavy, it may be possible to get above it by going aloft. When this can be accomplished a good observation is obtainable.

Altitudes in Cloudy Weather.—When the mass of the sun or moon is visible, but the limbs ill-defined in consequence of an overcast sky or the body shining through a rain-cloud or light fog, the image of the mass may be brought down and the centre of this ball of light calculated and allowed to be cut by the horizon line. In this case no allowance is to be made for semi-diameter. The ship's position, determined by this method, will probably be a little in error, but as a makeshift the rule has its value.

Meridian Altitude of the Moon.—The astronomical mean time of the moon's meridian passage is given in the nautical almanac for every day of the month at Greenwich, and this time answers, within a few minutes, for all longitudes. Proceed to observe the altitude in the same manner as explained for the sun, but use no shade-glasses. If the horns of the moon are down it

will be necessary to measure the altitude of the upper limb; but if the horns are up the lower limb will be measured. When the moon is full, or nearly so, measure the lower limb always in preference to the upper limb. (See Latitude.)

Time Altitude of the Moon.—This is observed in exactly the same manner as described for a time altitude of the sun, omitting the shade-glasses and having regard to the upper and lower limbs as explained in Meridian Altitude of the Moon. (See Longitude.)

Meridian Altitude of a Planet.—The astronomical mean times of the meridian passages of the planets are given in the nautical almanac for every day of the month, and apply practically to all longitudes. Proceed in precisely the same way as explained for a meridian sight of the sun, but use no shade-glasses and do not take the semi-diameter into consideration. (See Latitude.)

Time Altitude of a Planet.—This is observed in exactly the same manner as described for a time altitude of the sun, omitting, of course, the shade-glasses. (See Longitude.)

Meridian Altitude of a Star.—The following method of approximating the star's altitude and placing the same on the sextant should be observed, as it insures against bringing down the wrong body:

When the latitude by dead-reckoning and the star's declination are of the same name, subtract them from one another, then subtract the remainder from 90°—the answer will be the rough altitude; but when the latitude by dead-reckoning and the star's declination are of contrary names, add them together and subtract their sum from 90°—the answer will be the rough altitude.

A few minutes before the time given in the star tables (in the

back of this volume) for the meridian passage, set the sextant, direct it either to the north or south horizons, according to the latitude of the ship and the declination of the body, and the star's image will be seen in the horizon-glass of the instrument; then make a perfect contact by the aid of the tangent screw, and wait for the star to reach its highest point, proceeding in the same manner as described for a meridian observation of the sun, it being understood that shade-glasses are not employed.

The declination of the star as compared with the latitude of the ship will always dictate the direction (north or south) in which to look for the horizon beneath the body. If the star's declination is north of the ship's position, the northern horizon will be used, but if the star's declination is south of the ship's position, the southern horizon will be used.

Dawn and twilight afford the best horizons for star observations. (See Latitude.)

Time Altitude of a Star.—This is observed in the same manner as described for a time altitude of the sun, only without making use of the shade-glasses. It is to be explained, however, that until the navigator has studied the heavens and become sufficiently familiar with them to locate the nautical stars when they are off the meridian, this method of finding the longitude cannot be employed by him. The superior size and brilliancy of the planets will always prove an unfailing guide when desiring to select one of those bodies, but confusion will at once arise in seeking to fix upon particular stars unless the observer is acquainted with their relative places. (See Fixed Stars; Longitude.)

Altitude of the Pole Star.—Simply throw the star's image to that part of the horizon which is directly beneath the body, proving the point of contact by oscillating the sextant, and note

the local apparent time at ship as shown by the clock. (See Latitude.)

Remarks.—Under the head of Sextant will be found full and practical directions for adjusting the instrument and reading the altitude. (See also Corrected Altitude; Quadrant; Octant.)

If the star telescope is used, be particular to observe as closely as possible in the centre of the field.

AMPLITUDE.—The bearing (never exceeding 90°) of a heavenly body at rising or setting. To ascertain the variation and deviation of a compass by employing an amplitude, proceed as follows:

To Find the Magnetic Amplitude.—Observe the sun to rise or set and note its magnetic bearing by the compass, pelorus, or alidade, which bearing will be named east so many degrees north or south at rising, but west so many degrees north or south at setting, as the case may be.

To Find the True Amplitude.—With the latitude by dead-reckoning to the nearest degree, and the sun's declination to the nearest half degree, enter table 39 and select the sun's true bearing, which will be named north if the declination is north, and south if the declination is south.

To Find the Whole Variation.—The difference between the compass bearing and the true bearing (subtracted if of the same name, but added if of different names) will be the whole amount of the compass variation, or the angle made with the true meridian by the compass needle, and it will be named as follows:

To Name the Variation.—Refer to a compass card and mark the points representing the bearings, then imagine the eye in the centre of the compass looking at the point standing for the magnetic (compass) bearing, and if the true bearing is to the

right hand of the magnetic bearing the variation is easterly, but if to the left hand it is westerly.

To Find the Deviation.—If the compass has no deviation, then the whole amount of the variation determined by the amplitude will agree with the variation given by the chart for the ship's position, but if they do not agree, their difference will be the deviation of the compass for that particular course the ship was heading at the time of the observation, and it will be named according to the following:

To Name the Deviation.—Suppose that the variation found by amplitude is 10° east, and the variation given by the chart is 5° west. Now as the chart tells us that the north point of our compass needle in order to be correct magnetic should be inclined 5° to the west of the geographical or true north, and we find by our observation that it is inclined 10° to the east, it stands that the compass has 15° of easterly deviation.

Again, suppose the variation found by amplitude is 8° east, and the variation given by chart is 3° east, it shows that the compass needle is deflected 5° too much to the east, hence easterly deviation.

Once more, suppose that the variation found by amplitude is 15° west and the variation given by chart is 13° west; it shows that the compass needle has 2° of westerly deviation.

AMPLITUDE TABLES.—True bearings of heavenly bodies at rising and setting, calculated for various latitudes and declinations.

ANEMOMETER.—An instrument that measures the force of the wind.

ANEROID BAROMETER.—An instrument that registers atmospheric pressure, its principle of construction being as fol-

lows: The weight of the atmosphere presses on a thin metal box from which the air has been extracted and which is kept from collapsing by a spring. To this box is secured by a mechanical arrangement the index-hand that moves around the dial or face of the barometer. When the atmospheric pressure increases a spring, acting on a lever, turns the hand to the right, and when the pressure decreases the hand turns to the left. (See Barometer.)

ANGLE.—The divergence of two lines starting from the same point. (See Angle of Incidence.)

ANGULAR DISTANCE.—Measured by an angle; a certain number of degrees of arc.

ANNUAL VARIATION.—The yearly change of the compass variation in the same locality, or the yearly change of declination and right ascension tabulated for the fixed stars.

ANTARCTIC CIRCLE.—The parallel of 66° 32′, which divides the south temperate from the south frigid zone.

APPARENT TIME.—Time calculated by the sun. When the sun crosses the meridian of the observer it is apparent noon where he is, as well as at all places on his meridian from pole to pole.

ARC.—A part of a circle. (See Diurnal Arc; Nocturnal Arc; Sextant.)

ARCTIC CIRCLE.—The parallel of 66° 32′, which divides the north temperate from the north frigid zone.

ARITHMETIC OF NAVIGATION.—The arithmetic of practical navigation is extremely simple and is included in the following:

Angular Measure.—

60 seconds (60″) make 1 minute (1′).
60 minutes (60′) make 1 degree (1°).

Time Measure.—

60 seconds (60 sec.) make 1 minute (1 m.).
60 minutes (60 m.) make 1 hour (1 h.).

To Convert Time into Arc.—Convert hours, minutes, and seconds into arc according to table 7 or by the following:

1 hour is equal to 15°, so multiply the hours by 15.
4 m. is equal to 1°, so divide the minutes by 4.
4 sec. is equal to 1′, so divide the seconds by 4.

To Convert Arc into Time.—Multiply the longitude by 4 and this will turn the degrees of arc into minutes of time, the minutes of arc into seconds of time, and the seconds of arc into what is known as thirds of time (a third is the name given to the sixtieth part of a second). By dividing by 60 these quantities will be reduced to hours, minutes, and seconds of time. (See table 7.)

Arithmetical Signs.—

= equal to, the sign of equality.
+ plus, the sign of addition.
− minus, the sign of subtraction.
× multiplied by, the sign of multiplication.
÷ divided by, the sign of division.

Addition of Degrees, Minutes, and Seconds.—

35° 30′ 20″	27° 27′ 56″
20° 20′ 30″	36° 57′ 49″
55° 50′ 50″	64° 25′ 45″

Subtraction of Degrees, Minutes, and Seconds.—

11° 12′ 10″	26° 35′ 42″
10° 10′ 10″	12° 45′ 50″
1° 02′ 00″	13° 49′ 52″

Multiplication of Degrees, Minutes, and Seconds.—

10° 10′ 10″	13° 59′ 58″
5	3
50° 50′ 50″	41° 59′ 54″

Division of Degrees, Minutes, and Seconds.—

2)40° 20′ 10″	2)37° 15′ 52″
20° 10′ 05″	18° 37′ 56″

Addition of Decimals.—

6.5	7.9
5.2	6.9
3.2	4.9
14.9	19.7

Subtraction of Decimals.—

19.7	29.5
4.3	13.6
15.4	15.9

Multiplication of Decimals.—

20.1	15.6
5	4
100.5	62.4

Division of Decimals.—

2)18.4	2)17.6
9.2	8.8

ARTIFICIAL HORIZON.—A small trough filled with quicksilver, which latter is protected from the ruffling effects of the wind by a glass roof. It is used on shore to catch the image of a heavenly body and to measure its altitude for the purpose of determining the latitude and longitude. A pan of

molasses or liquid tar has often been employed with fairly good results, in the absence of a regular artificial horizon.

The theory of the artificial horizon is based upon the established principle that the angle of reflection is equal to the angle of incidence—that a ray of light striking a plane-reflecting surface will leave it at the same angle precisely.

Rules.—Place the trough on firm ground and as free from the wind as possible so that the surface of the liquid may not be disturbed, then face the heavenly body and step backward until its reflection is seen in the quicksilver. The image will now be brought down by the sextant until it is in contact with the other image in the trough, and the angle shown on the sextant will be double the altitude of the body, consequently it will be divided by 2.

When observing the lower limb of the sun in the morning the images will separate, but in the afternoon they will close.

In the case of the sun, if the nearest limbs of the two images are brought in contact half of the angle obtained by the sextant will be the altitude of the lower limb, but if the farthest limbs are brought in contact half of the angle obtained will be the altitude of the upper limb, and the semi-diameter will be applied according to the regular rules given for the sun under the head of Corrected Altitude. The sun's altitude obtained must also be corrected for parallax and refraction, but not for dip, because that quantity is eliminated by the use of the artificial horizon.

When ready to observe the altitude for a time sight it is best to separate the images or overlap them a trifle, as the case may require; then wait, in the first place, for them to kiss (close), or, in the second place, for the limbs to all but part, and at such instant of perfect contact note the Greenwich time and proceed to find the place of the observer by the given rules.

Before observing an altitude the glass roof should be carefully wiped clean, and if dust-scum is seen to rest on the surface of the mercury it should be brushed off.

When equal altitudes are observed be sure to measure the same limb in the P.M. that was measured in the A.M.; otherwise the result will be unsatisfactory.

It is to be explained that when a heavenly body is much more than 60° above the horizon it cannot, as a rule, be measured by an artificial horizon, because on the majority of sextants the reading does not go far above 120°.

ASTRONOMICAL DAY.—This commences at noon of the civil day, the hours being counted numerically from 1 to 24, so that the day begins and ends at noon.

ASTRONOMICAL TIME.—The civil day begins at midnight, twelve hours before the astronomical day, which commences at noon. To convert civil time into astronomical time it is only necessary to proceed as follows:

If the civil time is A.M. take one from the date and add 12 to the hours; but if the civil time is P.M. simply take away the sign P.M., and the answer will be the astronomical time.

To change astronomical time into civil time, if the hours are less than twelve, simply write P.M. after them; but if the hours are more than twelve subtract twelve hours from them, call the remainder A.M., and add 1 to the days of the month.

ASTRONOMY.—That science which treats of the heavenly bodies, their orbits, distances, etc.

AUGMENTED ALTITUDE.—Increased altitude; the correction in arc added to an ex-meridian altitude.

AUTUMNAL EQUINOX.—The period of the year when the sun crosses the equator from northern into southern declina

tions. This is known as the First Point of Libra. (See Spring Equinox.)

AXIS.—A line on which a body is supposed to revolve.

AXIS OF COLLIMATION.—The line of sight in an instrument, being the line which passes through the centre of the object-glass and the intersection of the wires placed in its focus. What is known as the error of collimation is the difference between the actual line of sight and the position which that line should have in reference to the axis of motion of the instrument. Should the line of sight of the telescope be inclined to the plane of the instrument, instead of perfectly parallel to it, all angles measured by the sextant will be too great.

AZIMUTH.—The bearing (never exceeding 180°) of a heavenly body calculated from the north or south points of the heavens. To ascertain the variation and deviation of the compass by an azimuth, proceed as follows:

To Find the Magnetic Azimuth and Time.—Observe the sun's bearing by compass, alidade, or pelorus, and note the local time shown by the ship's clock, which latter correct by adding to it four minutes of time for every degree of longitude sailed east since the clock was last set, but by subtracting four minutes for every degree sailed west.

In north latitudes A.M. azimuth bearings are counted north so many degrees east, and P.M. azimuth bearings are counted north so many degrees west.

In south latitudes A.M. azimuth bearings are counted south so many degrees east, and P.M. azimuth bearings are counted south so many degrees west.

To Find the True Azimuth.—With the corrected local apparent time and the latitude of the ship to the nearest degree

by dead-reckoning, also the declination of the sun to the nearest degree, enter the azimuth tables and select the sun's true bearing.

To Find the Whole Variation.—The difference between the compass and true bearings (always found by subtracting one from the other) will be the whole amount of the variation of the compass needle from the true north, and it will be named as follows :

To Name the Variation.—Refer to a compass card and mark the two points representing the bearings, then imagine the eye in the centre of the compass looking at the point standing for the magnetic (compass) bearing, and if the true bearing is to the right hand of the magnetic bearing the variation is easterly, but if to the left hand, it is westerly.

To Find the Deviation.—If the compass has no deviation, then the whole amount of the variation determined by the azimuth will agree with the variation given by the chart for the ship's position, but if they do not agree their difference will be the deviation of the compass for that particular course headed by the ship at the time of the observation, and it will be named according to the following :

To Name the Deviation.—Suppose that the variation found by azimuth is 7° west and the variation given by chart is 9° east. Now as the chart tells us that the north point of our compass needle in order to point correct magnetic should be inclined 9° to the east of the geographical or true north, and we find by our observation that it is inclined 7° to the west, it stands that the compass has 16° of westerly deviation.

Again, suppose that the variation found by azimuth is 14° west and the variation given by chart is 6° west : it shows that the compass needle is deflected 8° too much to the west, hence westerly deviation.

Once more, suppose that the variation found by azimuth is 20° east and the variation given by the chart is 19° east : it proves that the compass needle has 1° of easterly deviation.

AZIMUTH ATTACHMENT.—A small, portable, mechanical device, consisting of two revolving arms or sight-vanes, for resting on the compass-glass and by which bearings are taken. (See Alidade ; Pelorus.)

AZIMUTH CIRCLE.—Another name for an azimuth attachment.

AZIMUTH COMPASS.—A portable, dry-card compass provided with sight-vanes and used for taking bearings. It is now obsolete.

AZIMUTH MIRROR.—A small, portable instrument provided with a silvered glass and used for taking bearings. It steps in a small, shallow hole bored in the centre of the compass-glass, and is turned around until the image of the desired object is seen in the mirror, when its bearing is read. (See Alidade ; Azimuth Attachment ; Pelorus.)

AZIMUTH TABLES.—True bearings of the sun calculated for various latitudes, declinations, and times from sunrise to sunset.

BACK SHADES.—(See Sextant.)

BAROMETER.—An instrument for measuring the weight or pressure of the atmosphere, and sometimes referred to as a weather-glass, as it indicates the probable changes in the weather. The normal condition or average standing of the barometer for the sea-level is about thirty inches. As a rule, when the barometer continues steady, settled weather may be anticipated ; but if it is unsteady, a change is promised. A sudden rise of the

barometer is nearly as bad as a sudden fall, as it proves that the equilibrium of the atmosphere is unsettled. The average range (rise and fall) of the barometer in the higher latitudes is 1.5 (one inch and five-tenths) ; in the intertropical parallels from 0.2 to 0.4 (two to four-tenths), and near the equator only 0.15 (fifteen-hundredths of an inch). In hurricanes the barometer ranges from 1.0 to 2.5 (one to two and a half inches)—the rapidity of the fall increasing as the storm-centre approaches.

On the mercurial barometer the scale is spaced off in inches, whence is derived such terms as "the barometer stands at thirty inches," etc., meaning in this instance that the level of the mercury in the glass tube is opposite the thirty-inch division of the scale. (See Aneroid Barometer ; Mercurial Barometer ; Law of Storms ; Weather.)

BASE-LINE.—The lowest side of a geometrical figure ; at a right angle to the perpendicular.

BEARING.—The direction of one object from another according to the compass. (See Alidade ; Azimuth Attachment ; Pelorus.)

BELOW THE POLE.—When the north star is situated so that the pole is intercepted between it and the observer, it is said to be below the pole. This applies to other circumpolar bodies. (See Latitude ; Upper Transit.)

BOXING THE COMPASS.—(See Compass.)

CARDINAL POINTS.—North, East, South, and West. (See Intercardinal Points.)

CELESTIAL.—Relating to the heavens.

CELESTIAL CONCAVE.—The heavens.

CHART.—A marine map showing coasts, shoals, etc., etc.

All charts are projected true (parallels and meridians geographical), but the compass diagrams printed on them may be either true or magnetic, as described under the head of Chart Sailing. The parallels are represented by straight lines drawn true east and west across the chart, and the meridians by straight lines drawn true north and south. If the degrees and minutes marked on the right and left hand margins of the chart increase upward, the chart represents north latitudes, but if they decrease upward the chart represents south latitudes. If the degrees and minutes marked on the top and bottom margins of the chart increase toward the right hand, the chart represents east longitudes, but if they decrease toward the right hand the chart represents west longitudes. Charts are drawn on a large scale or a small scale according to the extent of ocean or coast to be delineated, and it is to be understood that buoyage, lights, soundings, etc., are fully explained on the charts representing the waters they refer to, and such explanations and directions as are given apply especially to that particular chart on which the details are read.

Buoys are marked B. (black), Cheq. (chequered), H. S. (horizontal stripes), R. (red), W. (white), B. W. (black and white), B. R. (black and red), R. W. (red and white), V. S. (vertical stripes). Buoys painted with black and white perpendicular stripes mark a mid-channel and must be passed close to to avoid danger. A green buoy marks a wreck. Perches with balls, cages, etc., mark turning-points in the channel. On the coast of the United States, when approaching a channel from seaward, red buoys with even numbers are left on the starboard side, and black buoys with odd numbers are left on the port side. Buoys painted with red and black horizontal stripes indicate obstructions with channel-ways on either side.

The quality of the bottom is expressed in abbreviations, as

follows: blk. (black), b. (blue), bkn. (broken), br. (brown), cl. (clay), co. (coarse), crl. (coral), d. (dark), f. (fine), gy. (gray), g. (gravel), gn. (green), grd. (ground), h. (hard), m. (mud), oz. (ooze), oys. (oysters), peb. (pebbles), rd. (red), r. (rock), rot. (rotten), s. (sand), sh. (shells), sft. (soft), spk. (speckled), stf. (stiff), st. (stones), wd. (weed), w. (white), y. (yellow).

Soundings, unless otherwise specified, are indicated according to the following: The numerals marked on the white surfaces represent the depth of the water at that point in fathoms (six feet), and when marked on the dotted surfaces they indicate the depth in feet (12 inches). All soundings are given for mean low water, and the rise of the tide at the given place is to be added to the sounding to ascertain the greatest depth of water at high tide at that particular point.

During fog or falling snow, vessels approaching light-ships will be warned by the alternate ringing of a bell and the blowing of a fog-horn.

Lights are shown by a dot of yellow having a red spot in the middle, and if any uncertainty exists concerning the character of a light it is simply marked Lt. Other abbreviations and their significance are as follows: F. (fixed), Fl. (flashing), Int. (intermittent), Rev. (revolving), F. and Fl. (fixed and flashing alternately), Flg. (floating), Lt. Ves. (light-vessel). When no color is expressed the light may be taken to be white. Whenever the color is given the word is spelled in full, as red, etc.

Currents are shown by a feathered arrow; the direction of the same indicating the flow of the current. Flood-tide stream is indicated by an arrow feathered on one side only, and ebb-tide stream by an unfeathered arrow.

Rocks just below the surface of the water are shown by a small dotted circle having a cross in the centre. Rocks awash

or just above water are shown by a dotted circle with one or more dots inclosed according to the number or extent of the rocks indicated. A dotted circle with a numeral in it signifies a shoal with the number of feet or fathoms over it. Either a rock, an island, or a shoal marked E. D. signifies existence doubtful, and if marked P. D., it means position doubtful, although known to exist. (See Pricking Position.)

Mercator's Chart.—This is the chart universally adopted as the only proper chart for general navigation. The parallels and meridians are all straight parallel lines, but the meridians only are equidistant. The distance between the parallels increases from the equator toward the poles in proportion as the meridians converge. This chart projection is constructed by the aid of the table of meridional parts and the rule given in Bowditch.

On the surface of the globe the parallels of latitude are everywhere equidistant, while the distance between the meridians lessens as we proceed polarwise. Thus it will be appreciated that if on a plane chart the parallels are retained equidistant while the meridians are widened out in order to show them as straight lines and as far apart in the vicinity of the poles as they are at the equator, there must be considerable distortion in one direction—namely, the longitude. This difficulty of delineation may be surmounted and the relation between the principal parts maintained by also distorting the chart polarwise or in a north and south direction; consequently the distance between the parallels is widened in the same proportion that the meridians have been widened. Of course this will distort the land and sea more and more in the parallels approaching the poles, but as the scale on the right and left hand margins of the chart allows for this, and as the contour of the countries is

preserved, as well as the relative directions from one point to another, no inconvenience is experienced by the navigator. (See Chart Sailing.)

Chart of the Inclination.—A chart which shows the dip of the magnetic needle for various latitudes and longitudes.

Coast Survey Chart.—A chart of the coast published by Government.

General Chart.—A chart embracing a large expanse of ocean or extent of coast.

Harbor Chart.—A chart, as its name implies, which delineates a harbor.

It is a detached portion of a general chart and is shown on a large scale. As a rule the parallels and meridians are not shown on harbor charts, and the scale is given in miles.

Physical Chart.—A chart showing ocean currents, winds, ice limits, etc.

Great Circle Chart.—A chart constructed specially so that all great circles are represented as straight lines. This answers the same purpose for great-circle sailing that Mercator's chart answers for rhumb-sailing. The construction of the great-circle chart is such that a straight line drawn on it connecting the place of departure with the place of destination gives immediately the great-circle track.

Hydrographic Charts.—Charts published by the Washington Hydrographic Office, which delineate the navigable waters of the world, rocks, shoals, tides, currents, depths, etc., and give the varied information in a convenient form for the navigator. The surveys are made by American naval officers and the charts are published by the United States Government.

Variation Chart.—A chart of the world on Mercator's projection, on which is represented the variation of the compass in

different latitudes and longitudes by a series of curved lines; also known as an isogonic chart.

CHART SAILING.—This ebmraces several considerations, which will be taken up in order.

To Shape the Course.—Place the same bevelled edge of the parallel rules over the ship's place and the point bound to; then, preserving the angle, slide the edge to the nearest compass diagram printed on the chart until it lies on the dot in the centre; now read the compass-point looking toward the place sought, and that will be the required course. (See Course Protractor; Graduated Rulers.)

In case the distance between the two places is too great to be reached by the parallel rules, take a piece of string and stretch it from one point to the other by the aid of pins stuck in the chart through the two places; then lay the bevelled edge of the rule against the string to obtain the angle, and proceed as before explained.

To Allow for Variation.—On some charts the north and south line of the diagram compass is parallel with the meridian line, while on other charts the north and south line of the diagram compass forms an angle with the meridian line. In the latter case it proves that the diagram indicates magnetic directions; consequently the course found by the parallel rules will be steered (unless deviation exists), as the diagram on the chart is a reflection of the compass on board the vessel. On the other hand, where the north and south line of the diagram compass is parallel with the meridian, it proves that the diagram indicates true or geographical directions. In this case it becomes necessary to allow for the variation of the compass as follows:

Example.—Suppose that the course found by a true compass

diagram is north and the chart tells us that where the ship is situated there is one point of westerly variation, which means that the north end of the compass needle is inclined one point to the west of the true or geographical north. Under these circumstances, it will be necessary to steer north-by-east by the ship's compass in order to make a true north course.

Note.—A simple rule to remember for converting true courses into magnetic courses is to allow the amount of westerly variation away from the true course in the direction that the hands of a watch revolve, and easterly variation contrary, or against the hands of a watch.

To Allow for Deviation.—If deviation exists for the correct magnetic course found, then the correct magnetic course must have the amount of the deviation applied to it on exactly the same principle as explained for variation in the preceding paragraph.

Example.—The correct magnetic course is east and there is one point of westerly deviation to be allowed when the ship's head is on that course; consequently the compass course to be steered is east-by-south in order to make a correct magnetic east course.

Always apply the variation before applying the deviation.

To Measure the Distance.—On a large scale chart, as for example, Long Island Sound, take off five miles or more between the points of the dividers, measuring from the latitude scale on the side of the chart, then see how many times this span is contained on the line of the course.

On a chart of small scale, such as an ocean chart, find the middle latitude between the two places, then take off one or more degrees from this middle point, which will give the average length of a degree in those latitudes. If sailing on a

parallel (an east or west course) set the dividers to the scale opposite the parallel.

The reason for setting the dividers to the scale opposite the parallels to be sailed in is on account of that particular scale belonging to those parallels. As explained under the head of Charts, the distance between the parallels increases from the equator toward the poles, consequently the scale given for the parallels near the equator will not answer for higher latitudes.

The two graduated parallels (top and bottom margins on borders) on the chart are marked in degrees and minutes, but on these parallels longitude-in-arc is measured, nothing more; distance cannot be taken from them, and they are only employed for laying off the longitude.

Cross-Bearings.—Observe in quick succession the compass-bearings of two lights (or other stationary objects which are defined on the chart), then refer to the chart, and by the aid of the parallel rules and the magnetic diagram compass draw pencil lines along the paper from the lights in question, according to the respective bearings of the two objects, and the point where the lines cross will show the position of the ship at the time the bearings were taken.

Remarks.—It is to be understood that the compass bearings are to be corrected for the deviation (if any exists) of the ship's head at the time the bearings were taken, so as to convert them into correct magnetic bearings before applying the lines to the chart.

It must be remembered that if the chart is provided with true, instead of magnetic compass diagrams, the variation of the compass must also be applied to the respective bearings in order to convert them into true bearings; then these latter must be transferred to the chart, plotting them from the true compass diagram.

Vertical Danger Angle.—The danger angle has, to a great extent, taken the place of cross-bearings for locating the position of a vessel when in sight of lighthouses, either by day or night. It is extremely easy of solution, and by the aid of the danger-angle tables to be found in the back of this little volume the navigator will discover it to be a very simple matter, both to fix the position of his ship and to keep outside of dangers in the way of rocks and shoals situated at a distance from the shore. (See Danger-Angle Tables.)

First Consideration.—To determine the place of the ship, take a compass-bearing of any lighthouse in sight; the vessel will be somewhere on this line of bearing. Then with the sextant measure the altitude of the light by throwing the reflection of the lantern to the water line. By consulting the danger-angle tables with the measured angle and the height of the light above the sea-level (the latter is given on the chart) the distance of the vessel seawards from the light will be read in the side column to the left.

Second Consideration.—To explain another practical application of the vertical danger angle, let it be supposed that a vessel is forced to closely round a lighthouse, at some distance seawards of which there is a cluster of rocks a few feet under water. Now with the dividers measure the distance from the light to a point well outside of the danger, then with this distance and the height of the light enter the danger-angle tables and read the angle given. Place this angle on the sextant and when approaching and passing the light observe that this angle does not *increase*, otherwise the ship will be inside the danger mark. If the angle decreases the ship will be farther outside the danger mark than there is necessity for.

Remarks.—In measuring vertical danger angles, when the

lighthouse is comparatively close, the observer should get as near to the surface of the water as the deck will admit in order to reduce the error arising from the eye being elevated above the sea-level. It is to be explained, however, that if this point is disregarded altogether, the slight error will lie on the *safe* side, so long as there exists no danger seawards of the ship.

If the sextant has an index-error the same must be allowed for in measuring danger angles. (See Sextant.)

Horizontal Danger Angle.—Where the vertical danger angle is dependent upon a lighthouse, the height of which is known, the horizontal danger angle may not only be worked by two lighthouses independent of their height, but in the daytime it may be employed by using any two well-defined objects on shore, such, for instance, as prominent features of the coast-line, buildings, etc. In the horizontal danger angle no tables are used, the navigator calculating his own angle.

We will suppose that the chart shows a number of rocks or shoals stretching for some little distance along the coast, and that back of them on the shore are a life-saving station and a church. Sweep the smallest circle with a pencil-point dividers that will pass through the two shore objects and inclose all the dangerous features between them. Now from a seawards point on this circle, draw lines to the two objects on shore so that the lines will look like the plotting of a cross-bearing. The respective directions of these two lines will be measured by the parallel rules and the nearest chart compass, and the angle shown by the divergence of the lines will be turned into degrees. This angle will be placed on the sextant, and when approaching and passing the danger the navigator will observe that the angle does not *increase*, otherwise he will know that he is inside the danger

line. If the angle decreases it is a sign that he is outside or seawards of the danger line.

As its name implies, this angle is measured by holding the sextant horizontal and sweeping one object into the other.

It matters not from what seawards point of the circumference of this circle the angle is measured—it will give the same result; consequently by steering the ship so as to preserve the given angle, the navigator would sail right around the circle drawn by the pencil-point dividers.

Example.—We will suppose that off a section of the coast defined by two headlands, several clusters of rock are shown to extend between them and to lie off shore at a distance of two miles. Our course being close along the coast it is necessary to take precautions in approaching and passing this dangerous point.

By the aid of a pencil-point dividers (or a small piece of lead-pencil fastened to one leg of the common dividers) we sweep a circle which passes through the headlands and incloses every part of the shoal. Next we draw two pencil lines from a seawards point on this circle so that they will pass through each headland; then we determine their respective bearings by the parallel rules and the chart compass.

One headland, we will say, we find to bear north-northeast, and the other northwest. These bearings equal six compass-points, or 67°; consequently this is the horizontal danger angle, and we place the same on the sextant and observe that it does not increase as we approach and pass the shoal.

Four-Point Bearing.—This is an extremely simple and useful problem. When approaching a lighthouse, light-vessel, or a point of land, note its compass-bearing when it is four points on the bow. When the object is exactly abeam calculate the

distance run from the time the first bearing was taken, and this will be the distance of the ship from the light abeam.

Example.—A ship is steering north, making ten knots per hour. At 7 o'clock a lighthouse bears northwest, and at 7.30 o'clock it bears west, or directly abeam. The distance run in the interval is five miles ; consequently the ship is five miles east of the light.

Remarks.—The ship is not supposed to change her course in the interval between bearings.

In this problem the deviation of the compass is not considered, as the vessel maintains the same course ; consequently, the deviation being the same for both bearings, it is ignored.

An object to bear directly abeam must subtend an angle of eight points of the compass, or 90°, to the ship's course ; for example, if a ship is steering northwest, an object will be directly abeam on the port side when it bears southwest, and directly abeam on the starboard side when it bears northeast.

Patterson's Method.—This conception of the author's affords the means of locating the vessel by two compass-bearings of the same object when in sight of land, where only a single light, headland, or other fixed feature is to be seen.

Rule.—Observe the bearing of the object and note the time. After holding the course until the object has changed its bearing at least two or three points, note again its bearing and the time, and calculate the distance the vessel has run in the interval between the first and last bearings. Trace the two lines of bearing on the chart in pencil, then span the dividers to the distance run, and proceed as follows :

With the parallel rules set to the course sailed by the ship between bearings, move them along the pencil lines until both points of the dividers, held against the bevelled edge of the rules,

just fit across the lines, and these two points where the dividers rest will show the position of the vessel at the time of the first bearing as well as her place at the time of the second bearing.

Remarks.—The two compass-bearings must be corrected for the deviation (if any exists) of the ship's head at the time the bearings were taken, so as to convert them into correct magnetic bearings before tracing them on the chart.

The compass course must also have the deviation applied to it so as to reduce it to a correct magnetic course before setting the parallel rules by the diagram compass on the chart.

CHIP LOG.—This log can claim at least one advantage over the patent log, inasmuch as the vessel's rate of speed can be determined by it at any given instant, whereas the patent log is useful only for recording a considerable distance run.

The log line should be about one hundred and fifty fathoms long and marked off in knots, the distance between which should stand for the same part of a sea mile as the 30 seconds sand-glass stands for an hour—namely, the 120th part—which would make the lengths between the knots about fifty-one feet. When a 28 seconds glass is used the length between the knots should be about forty-seven feet.

It has been found, however, from practical experience, that the chip log records somewhat less than it should owing to the log coming home after being hove. To compensate for this, navigators should shorten the distance between the knots so that for a 30 seconds glass they should be forty-eight feet apart, and for a 28 seconds glass, forty-five feet apart.

Heaving the Log.—One man holds the reel and another the sand-glass. The officer throws the log chip over the ship's stern, and when he observes that the stray line is run off (about ten fathoms—this distance being allowed to carry the log out of the in-

fluence of the ship's wake), he calls "turn ;" the seaman upsets the glass and watches until the sand is run out, then calls "stop." The officer stops the line by a sudden jerk which pulls the plug out of its hole in the chip and so allows the log to float horizontal, then observes the number of marks that have passed over the taffrail. The last mark shown indicates the knots, and the distance of the mark outside of the taffrail shows the fractions of the knot estimated in eighths (eight furlongs to the mile). The knots and furlongs give the speed of the vessel in nautical miles or knots.

Remarks.—When running before a heavy sea, allowance must be made, for the ship will make greater speed than indicated by the log. Under such conditions it is customary to add one mile for every ten knots run out.

Driving against a heavy sea it is the rule to subtract one mile for every ten knots run out.

In heaving the log, the line must be helped from the reel by the officer, so that no strain is brought upon the chip as it rests in a perpendicular position in the water ; otherwise the wooden peg which forms a part of the bridle will pull out and the log will lie flat on the surface.

The line must be measured occasionally, and if it is found to be stretched, it must be carefully remarked, otherwise it will prove deceptive.

Compare the sand-glass at times with a watch to see that it runs out in the prescribed number of seconds.

The glass is more or less influenced by the weather, running slower in a damp atmosphere than in a dry one.

In case of accident to the sand-glass, time the log-line by a watch.

When a vessel is going at a high rate of speed it is usual to use

a 14 seconds glass and then double the indicated number of knots: this saves the paying out of a long length of line and the attendant effort of hauling it in.

The first knot on the log line is measured from the white rag, which terminates the ten fathoms allowed to drift the chip far enough astern to be out of the eddies of the wake. When this white rag passes over the taffrail the sand-glass is turned.

CHRONOMETER.—A marine time-piece constructed with the idea of great accuracy, and set to the time of some first meridian. The Americans and English use the time of the meridian of Greenwich; the French that of Paris, etc.

Care of Chronometers.—Chronometers should be wound at the same hour each day, the key being turned gently so that no shock may be imparted when the key butts. They should be stowed as near the centre of motion as possible, and the temperature near them kept as uniform as possible. When transported by hand they should be clamped securely by the clamp-screw, to prevent them from swinging about in their gimbals. In winding a chronometer the instrument is to be inverted with the left hand and the key turned with the right. At all times, except when being transported by hand, the chronometer must be left to swing freely in its gimbals, like a compass. Never stow a chronometer close against an iron bulkhead, or near an iron stanchion, or, beyond all, near spare compasses or artificial magnets, otherwise magnetism will be induced into the steel balance and ruin the going of the chronometer. Avoid placing a chronometer in the after-end of a screw steamer on account of the vibration. When a chronometer is being transported by hand be careful not to knock it against anything or to give it a sudden twist. (See Rate.)

CHRONOMETER COMPARISON. — To determine the error of a chronometer by observatory clocks or by comparing the longitude of the ship found by observation with the known longitude of a visible point of land.

CHRONOMETER RATE.—(See Rate.)

CHRONOMETER-TIME SIGHT.—(See Longitude.)

CIRCUM - MERIDIAN ALTITUDE. — An altitude of a heavenly body observed a short time before or after its meridian passage. This is also known as an ex-meridian altitude. (See Latitude.)

CIRCUMNAVIGATE.—To sail completely around. To sail around the world is to circumnavigate it.

CIRCUMNAVIGATOR'S DAY. — In circumnavigating the globe by sailing west the ship and the sun move in the same direction, but by sailing east the ship and the sun move in opposite directions. In the former case the sun overtakes the ship, and in the latter case the sun advances to meet the ship. Therefore in sailing west the ship's day is lengthened and in sailing east it is shortened at the rate of one hour for every 15° of longitude made.

Should a vessel start from Greenwich and sail east until the meridian of 180° was reached, arriving at that point at 2 o'clock in the morning of Sunday, the 20th day of the month (according to the ship's date and time), it would only be 2 o'clock in the afternoon at Greenwich on Saturday, the 19th. Thus the ship's time would be twelve hours ahead of the time at Greenwich. Now if the ship, without changing her date, continued sailing to the eastward until Greenwich was reached, another twelve hours would be gained, and the ship's time would be twenty-four hours, or one day, ahead of the Greenwich time.

On the other hand, should a vessel start from Greenwich and sail west until the meridian of 180° was reached, arriving at that point at 2 o'clock in the morning of Sunday, the 20th day of the month (according to the ship's date and time), it would be 2 o'clock in the afternoon of the same day (Sunday, 20th) at Greenwich, so that the ship's time would be twelve hours behind the Greenwich time. If the ship, without changing her date, continued to sail to the westward until Greenwich was reached, another twelve hours would be lost, and the ship's time would be twenty-four hours, or one day, behind the Greenwich time.

Rule.—When crossing the meridian of 180°, if the ship is sailing eastward, the navigator must *reckon the given day over again*, so that there will be two Sundays, or Mondays, or Tuesdays, etc., in the log-book for that particular week, according to the day that he crosses. By doing this the ship's date will be found to correspond with the Greenwich date when the vessel reaches that port.

But when crossing the meridian of 180°, if the ship is sailing westward, the navigator must *skip a day*, so that there will be a Sunday, or a Monday, or a Tuesday, etc., omitted in the log-book for that particular week, according to the day that he crosses. This insures the ship's date agreeing with the Greenwich date when the vessel reaches the latter port.

Warning.—The great point for the navigator to bear in mind is that he is not to interfere with the Greenwich date shown by the chronometer, but that he is religiously to keep the run of and hold on to same, and select the sun's declination, equation, etc., from the nautical almanac for the *Greenwich date*, and correct the hourly difference of declination, etc., according to the regular rule given under the head of Declination.

Examples.—A ship leaves Greenwich and sails *east*, reaching

the meridian of 180° on Sunday, the 20th (according to the ship's date). Instead of calling the next day Monday, the 21st, it must be considered again as Sunday, the 20th, so that two Sundays and two 20th days for that month will appear in succession in the log-book.

A ship leaves Greenwich and sails *west*, reaching the meridian of 180° on Sunday, the 20th (according to the ship's date). Instead of calling the next day Monday, the 21st, it must be considered as Tuesday, the 22d, so that there will not appear either a Monday or a 21st day for that month in the log book.

CIVIL TIME.—The civil day consists of twenty-four hours; it commences at midnight, and the first twelve hours are called A.M., and the latter twelve hours are called P.M. (See A.M. P.M.)

CLAMP-SCREW.—(See Sextant.)

CLOUDS.—(See Weather.)

COLLIMATION.—The line of sight in the direction of any object. (See Axis of Collimation.)

COMBINED ALTITUDE PROBLEM.—(See Sumner's Method.)

COMPASS.—The mariner's compass consists of a magnetized steel bar secured parallel to the north and south line of a circular card, which latter is balanced on a pivot so as to turn freely in the horizontal plane and to indicate the magnetic meridian. The surface of the card is divided into thirty-two courses with their intermediate quarters, and in addition to this all steamships have the circumference of the compass card graduated into degrees.

Boxing the Compass.—What is known as boxing the compass is calling the thirty-two courses in order from north by the

way of east, as shown on the diagram in front of this book. To box the compass backward is to call the courses from north by the way of west, or contrary to the order in which the hands of a watch revolve.

Points and Degrees.—By consulting the diagram it will be seen that compass courses are given a value both in points and degrees, the same commencing at the two poles of the circle (north and south) and ending at the equator line of the compass (east and west). Thus the north and south points are zero and the east and west points have a numerical value of 8 and an angular value of 90°.

Variation of the Compass.—The compass needle when uninfluenced by deviation points to the magnetic poles of the earth, and as these do not coincide with the true or geographical poles, the magnetic meridians form an angle with the true meridians, and this is called the variation of the compass, which varies in extent in different parts of the world. The magnetic north pole is situated on the parallel of 70° north and the meridian of 97° west. The magnetic south pole is situated on the parallel of 73° south and the meridian of 146° east.

Over the North Atlantic, the greater part of the South Atlantic, and the Indian Ocean, the variation is westerly, and over a part of the South Atlantic and in the Pacific the variation is easterly. There are places on the surface of the globe where variation does not exist, or in other words, where the compass points true north, and these places are said to be situated on the line of no variation. One of these lines runs through Eastern Europe, Asia, and Australia; the other through North America, the eastern part of South America, and the southwestern part of the South Atlantic Ocean.

The magnetic equator is not the same as the earth's equator,

but an irregular line running round the globe, near the earth's equator, which it crosses in two places, one near the west coast of Africa, the other about the middle of the Pacific Ocean.

The variation of the compass is not constant, but undergoes an annual change, and the amount of this yearly increase or decrease will be found plainly marked on charts.

Deviation of the Compass.—What is known as the deviation of the compass is the deflection of the needle from the *magnetic* meridian, caused in iron sailing ships by the attraction of the hull and iron lowermasts, and in an iron steamship by the attraction of the hull, machinery, smokestack and masts. In addition to this it must be understood that deviation is often caused by certain elements of magnetism in the cargo. The manner of ascertaining the existence and extent of compass deviation will be found explained under the heads of Amplitude and Azimuth. When shaping a course, or when taking compass-bearings, the deviation existing for the ship's head must be considered, as explained under the head of Chart Sailing. Deviation is named east or west according as the north point of the compass is drawn to the eastward or westward of the magnetic meridian.

Deviation Card.—This is a tabulated account of the deviation of the compass for each one of the thirty-two courses, and directs the navigator as to the course to be steered by compass in order to make the required correct magnetic course. Deviation always refers to the ship's head. In other words, where deviation is given it means for a certain course. If the card tells us that for an east course the compass has 10° of westerly deviation, it signifies that when the ship heads east the north end of the compass needle will be drawn 10° to the westward of the correct magnetic north, and any bearing taken when the ship is

on such course must be corrected for 10° of westerly deviation, and not for the deviation given for the point represented by the bearing.

A deviation card refers to one particular compass, and to no other, consequently a course set or a bearing taken by a certain compass must have the deviation of that compass applied to it according to its own deviation card.

Residual Errors.—When a compass is affected by deviation it is sought to adjust it by placing artificial magnets in its vicinity, so as to draw the compass needle to the correct magnetic meridian, and the remaining deviations for the various courses are classed as residual errors.

Local Attraction of the Compass.—Elements of magnetism outside (away) from the vessel which influence the pointing of the compass. In sailing very close along some coasts where there are large deposits of iron ore or volcanic disturbances the compass has been found to be slightly and temporarily drawn away from the correct magnetic north. It will be understood that, as its name implies, this disturbing quantity is purely local. A vessel's compass is often affected when lying alongside of a dock or other vessel, owing to the near presence of iron used in construction of same. (See Compensated, Demagnetized, Dry, Elevated, Liquid, Masthead, Oil, Pole, Spirit, Standard, Steering, and Tripod Compasses.)

COMPASS ADJUSTING.—Correcting a compass for deviation by placing artificial magnets in its immediate vicinity, so as to draw the north end of the compass needle to the correct magnetic north. As a rule compass adjusting is performed by professional adjusters, it being a profession in itself, although there are shipmasters who have made a study of the science, and in consequence are able to dispense with outside talent. In the

case of the patent-adjusting-binnacle compass, where the magnets are contained in racks within the binnacle stand, full directions for adjusting the compass are furnished with the instrument.

COMPASS-BEARING.—The direction of an object according to one of the divisions of the compass card.

COMPASS CARD.—The circle to which is secured the magnetized bar of steel and on which circle the thirty-two compass courses are shown.

COMPASS CORRECTIONS.—Allowances for variation and deviation.

COMPASS COURSE.—The track made by a vessel according to one of the divisions of the compass card.

COMPASS NEEDLE.—The name often applied to the magnetized steel bar secured to the compass card.

COMPASS POINT.—One of the divisions of the compass card.

COMPASS ROSE.—The diagram compass on a chart is referred to in some works on navigation as a compass rose.

COMPENSATED COMPASS.—An adjusted compass; a compass that has been freed, to a greater or less extent, of its deviation by the employment of artificial magnets, the same being placed in close proximity to the compass, so as to draw the needle to the correct magnetic meridian.

COMPENSATING MAGNETS.—Artificial magnets used in compass adjusting. (See Magnet.)

COMPLEMENT.—The full number or quantity; what an altitude lacks of 90°. The zenith distance is the complement of the altitude.

CO-LATITUDE.—The complement of the latitude, or what it lacks of 90°; as, for instance, 50° is the co-latitude of 40°.

COMPOSITE SAILING.—This is a combination of great-circle and parallel sailing, and is adopted when the great-circle track, by passing in the neighborhood of ice, land, or other danger, becomes impracticable. In other words, it is a modification of the great-circle track. (See Great-Circle Sailing.)

CONSTELLATION.—A group of stars to which is given the name of some classical hero, beast, bird, fish, figure, etc. The Pole Star is in the constellation of Ursa Minor (The Little Bear), and the Dipper is in the constellation of Ursa Major (The Great Bear), etc. (See Fixed Stars ; Planets.)

CORRECTED ALTITUDE.—The observed altitude of a heavenly body, with allowances made for dip, refraction, etc. (See Eighty-Nine-Forty-Eight.)

Sun.—If the altitude of the sun's lower limb is measured, the semidiameter (Nautical Almanac) must be added, but if the upper limb is observed, the semidiameter must be subtracted, in order to obtain the altitude of the sun's centre from the horizon. For practical purposes the semidiameter of the sun may be called 16′.

Parallax (Table 16) is always added, because the body appears lower when viewed from the surface of the earth than it would if observed from the earth's centre—except when the body is in the observer's zenith when it has no parallax.

Dip (Table 14) is always subtracted, as the elevation of the observer's eye above the sea-level causes the navigator to measure too great an altitude.

Refraction (Table 20) is always subtracted, owing to the body

being seen above its true place, except when it is in the zenith of the observer, when it has no refraction.

Moon.—The semidiameter (Nautical Almanac) of the moon and the dip (Table 14) are applied in exactly the same manner as explained for the sun; but parallax in the case of the moon is large as compared with refraction, and it is so arranged that the moon's parallax (Table 24) is given minus the refraction, so that the figures selected from this table must always be added to the altitude. For practical purposes the semidiameter of the moon may be called 16′, the same as the sun.

Planets.—The altitudes of these bodies are corrected for dip (Table 14) and refraction (Table 20) as usual, but the correction for parallax involves a new process. With the planet's horizontal parallax (Nautical Almanac) and the observed altitude, find the planet's parallax (Table 17) by applying the first two quantities in their respective columns. The semidiameters of the planets are given in the almanac, and if used must be applied as usual, but it is to be explained that for practical purposes the altitude of a planet is never corrected for semidiameter and parallax.

Stars.—The altitudes of the stars are corrected for dip (Table 14) and refraction (Table 20) as usual; they have no apparent diameter or parallax.

Recapitulation.—Note the following:

Semidiameter is always added for the lower limb and subtracted for the upper limb.

Parallax is always added.

Dip is always subtracted.

Refraction is always subtracted.

It is to be remembered that the sextant's index error (if it has any) is always to be figured as an altitude correction. (See Sextant.)

CORRECTED COURSE.—As a preliminary to working out a ship's position by dead-reckoning, the compass courses that have been sailed are converted into true or geographical courses by correcting them for leeway, deviation, and variation.

Leeway.—The amount is determined as explained under the head of Leeway, and this quantity is allowed to leeward of the compass course. For example, if the course sailed was east and the vessel was on the starboard tack making one point of leeway, the same must be allowed toward the north, making the so far corrected course east-by-north.

Deviation.—Westerly deviation must be allowed away from the compass course in a direction contrary to the way that the hands of a watch revolve. For instance, if the course after being corrected for leeway is east-by-north, and there is one point of westerly deviation to be considered, the same must be allowed toward the north, making the correct magnetic course east-northeast. On the other hand, easterly deviation will be allowed away from the compass course in a direction the same as the hands of a watch revolve. To illustrate: if the course is east-by-north, and there is one point of easterly deviation to be considered, the same must be allowed toward the east, making, in this case, the course east.

Variation.—This is allowed in exactly the same way as explained for deviation, as will be seen following: we will say that the compass course after being corrected for leeway and deviation is east-north-east, and that there is one point of westerly variation to be considered. In this case the true or geographical track that the ship has made is northeast-by-east.

Again, suppose that the compass course after being corrected for leeway and deviation is east, and that there is one point of

easterly variation to be considered. In this case the true or geographical track that the ship has made is east-by-south.

Remarks.—When the variation and deviation are of the same name (both east or both west) they may be added together and applied.

If the variation and deviation are of contrary names they may be subtracted one from the other and the balance applied in the name of the greater of the two quantities.

It is to be explained that leeway made on the starboard tack is applied in the same direction as westerly variation and deviation, and that leeway made on the port tack is applied in the same direction as easterly variation and deviation ; consequently there are times when the three quantities of leeway, variation, and deviation may be added together and applied as a whole to a compass course.

CORRECTED LOCAL TIME.—To ascertain the correct local time at the ship, proceed as follows : to the sun's time shown by the ship's clock (set when the sun crossed the ship's meridian) add four minutes for every degree of longitude sailed east since the clock was last set, but subtract four minutes for every degree sailed west ; the answer will be the local apparent time at ship.

COURSE AND DISTANCE.—(See Chart Sailing ; Great-Circle Sailing ; Mercator's Sailing ; Middle Latitude Sailing.)

COURSE MADE GOOD.—The bearing of the vessel from the latitude and longitude last determined, irrespective of the traverse sailed. (See Dead-Reckoning.)

COURSE PROTRACTOR.—This consists of a half circle of thin horn or isinglass, having its circular edge graduated into degrees, and a long thread leading from the centre of the instru-

ment. To ascertain the course by this little contrivance place its zero line on any convenient meridian on the chart, then slide it up or down on this true north and south line until the thread lies in a straight line over the position of the ship and the place sought. The course between the two points will be indicated in degrees on the circle by the direction of the thread.

Remarks.—The course protractor always gives the true or geographical course, to which must be allowed the variation of the compass for the locality of the ship in order to convert it into a magnetic course. If deviation exists for the compass course found, then this quantity must also be applied. (See Chart Sailing.)

CROSS-BEARINGS.—(See Chart Sailing.)

CULMINATE.—When a heavenly body crosses the meridian of the observer it is said to culminate. Upper culmination is when a heavenly body crosses the meridian above the pole, and lower culmination is when it crosses the meridian below the pole. What is known as a moon-culminating star is one that comes to the meridian at the same time with the moon.

CURRENT.—A progressive motion of the water of the sea at a certain place ; an ocean river. The flow of a current is named according to the direction in which it sets, hence a northeast current comes out of the southwest and flows toward the northeast. (See Patent Log.)

CURRENT LOG.—Same as ground log, which see.

CURRENT SAILING.—When a vessel experiences a current, the effect is to set her in the direction of its flow. This must be considered as a regular and separate course, and the hourly velocity of the current is to be taken as the rate of speed made on such course, as shown following :

Example.—A ship while sailing southeast enters the Gulf Stream at a point where it is flowing northeast at the rate of two knots per hour, and remains in the stream ten hours. This data is recorded in the log-book, and when working out the dead-reckoning this course of northeast must be entered on the traverse table, and the distance of twenty miles considered as the number of knots sailed on that course.

Remarks.—The chart will give the flow of the current either as true or magnetic. If the former, no correction is to be applied to it after entering it on the traverse table ; but if the latter, then the variation must be applied in order to convert it into a true course. The deviation of the compass never enters into this consideration, because the direction is given by the chart. (See Patent Log.)

CUT.—When referring to the graduation of the sextant arc, it is said to be *cut* to ten minutes (10′), and the vernier is said to be *cut* to ten seconds (10″).

CYCLONE.—(See Law of Storms.)

DANGER ANGLE.—(See Chart Sailing.)

DANGER-ANGLE TABLES.—Tables that give by mere inspection the distance of a vessel from a certain object. In this consideration the known height of the lighthouse and the vertical angle of the same measured to the surface of the water are all that is required for the navigator to ascertain his distance from the object. The danger-angle tables found in the back of this book have been arranged by the author to the nearest 10″ of arc (that being the lowest graduation shown on sextants) and extend from thirty feet to three hundred and twenty feet. The manner of using these tables is explained under the head of Chart Sailing. To determine the distance of a vessel from a lighthouse

when beyond the limit of the figures in the danger-angle tables, the "Distance" table in the back of this book may be employed.

DARKS.—Having reference to those nights during which the moon is not seen in the heavens.

DAY. — (See Astronomical Day ; Circumnavigator's Day ; Gained Day ; Lost Day ; Lunar Day ; Sea Day ; Sidereal Day ; Solar Day.)

DAY'S WORK.—The calculation of the ship's latitude and longitude by dead-reckoning.

DEAD-RECKONING.—The position of the ship found by referring the true courses to the nautical tables and selecting for each course the respective amounts of latitude and departure, then applying the aggregate value of these to the latitude and longitude left. The manner of converting compass courses into true or geographical courses is explained under the head of Corrected Course.

To Find the Latitude and Longitude.—Convert the compass courses sailed into true or geographical courses by applying the leeway, deviation, and variation. With the distance made on each course, find separately (Table 1 or 2) the difference of latitude and departure. After selecting for all, foot the columns of the traverse table, and if both northing and southing have been made subtract one from the other ; also if both easting and westing have been made subtract one from the other.

Apply the difference of latitude to the latitude left, adding the same if the ship has sailed toward the poles, but subtracting if the ship has sailed toward the equator ; the answer will be the latitude by dead-reckoning.

Next turn to the page (Table 2) marked with the degrees of the middle latitude, apply the departure in the *latitude* column (read-

ing from top of page if the degrees of the middle latitude were found there, but from the bottom if the degrees were found there), and opposite to the left in the distance column will stand the difference of longitude. Apply this latter to the longitude left, adding the same if the longitude has been increased, but subtracting if the longitude has been decreased ; the answer will be the longitude by dead-reckoning.

To Find the Course and Distance.—With the difference of latitude and departure, make them compare (Table 2) in their respective columns opposite each other, and in the distance column to the left will be seen the distance in nautical miles made good, and the true or geographical bearing (called course made good) of the vessel from her former calculated position will be read in degrees from the top of the page if the difference of latitude is greater than the departure, but from the bottom of the page if the departure exceeds the difference of latitude.

Remarks.—If the vessel has been sailing in a current, or has been hove-to, or has taken farewell from the land, these are considerations for the traverse table. (See Current Sailing ; Departure ; Drift.)

Sailing-vessels steer by quarter points, but steamships steer by degrees, consequently in the former sailing, Table 1 is employed, and in the latter sailing Table 2 is made use of.

To select the difference of latitude and departure, apply the distance sailed on the particular course in the column marked "Dist." in the tables, then read the figures in the two right-hand columns. If the course was found at the top of the page the latitude and departure must be read from the top ; but if the course was found at the bottom of the page the latitude and departure must be read from the bottom.

DECLINATION.—The angular distance of a heavenly body

north or south of the equinoctial. Declination may be expressed as celestial latitude. The declinations of the sun, moon, planets, and stars are to be corrected as explained following:

Sun.—Select from the Nautical Almanac the sun's declination for Greenwich noon of the Greenwich date, and correct this for the hourly difference of declination by multiplying the latter by the number of hours that the chronometer showed before or past noon at Greenwich at the time the altitude was measured, and either add this correction to or subtract it from the declination given for Greenwich noon, according as the declination is increasing or decreasing. The idea is to ascertain the distance of the sun north or south of the equator at the time of observation. (See Inclination.)

Moon.—Convert into astronomical time and date the Greenwich time shown by chronometer when the moon's altitude was observed, calling the hours numerically from one to twenty-four instead of referring to them as A.M. and P.M. For example, if, when the observation was taken, the chronometer showed Greenwich civil time November 5th, 8 P.M., both date and hour would be astronomical, and would stand as such; but if the chronometer showed Greenwich civil time November 5th, 2 A.M., then call the astronomical date November 4th and the time fourteen hours. (See Astronomical Time.)

Now turn to the Nautical Almanac, and under the astronomical date and opposite the astronomical hour select the moon's declination given. Opposite to this to the right will be seen the moon's change of declination for one minute of time. Multiply this minute difference by the number of minutes over the even astronomical hour, and if the moon's declination is increasing add the correction to the declination given for the hour; but if the moon's declination is decreasing subtract the correction.

Planets.—The declination of a planet is given for Greenwich noon, and must be corrected in precisely the same manner as described for the sun—the hourly difference of the planet's declination being multiplied by the number of hours shown from Greenwich noon by the chronometer at the time of observation, and this correction either added to or subtracted from the declination of the planet given for Greenwich noon, according as the planet's declination is increasing or decreasing.

Stars.—The declinations of the stars being practically a fixed quantity, no correction is necessary for the declinations given for those bodies—accepting the declinations for the given year as shown in the Nautical Almanac being all-sufficient.

DEGREE.—The 360th part of the circumference of a circle. The value of a degree is 60′. A degree of latitude is equal to sixty nautical miles or knots, anywhere from the equator to the poles ; but a degree of longitude is equal to sixty nautical miles only on the equator. Leaving the equator, the distance between the meridians constantly contracts, so that at the poles there is no such thing as longitude, all the meridians meeting at those points. If it is desired to learn the distance between any two meridians on a certain parallel of latitude, simply open the nautical tables (Table 2) at the page marked with the parallel in question, then opposite the figures 60 in the distance column will be found (to the right) in the latitude column the number of miles between the meridians.

Examples.—On the parallel of 40° the distance between the meridians is forty-six nautical miles or knots ; consequently, if the ship started from the longitude of 74° and sailed forty-six nautical miles east on the parallel of 40°, she would reach the longitude of 73°.

On the parallel of 47° the distance between the meridians is 40.9 (forty and nine-tenths) nautical miles.

DEMAGNETIZED COMPASS.—A compass the needle of which has parted with its magnetism.

DEPARTURE.—The amount of easting or westing made by a vessel from a certain point. To "take departure" is to observe the bearing of and calculate the distance of the vessel from a lighthouse or other point when the harbor is cleared and the first course set. This is also known as "taking farewell."

Example.—Departure is taken, Sandy Hook light bearing west by compass, distant six miles. This is entered as a memorandum in the column of remarks in the log-book, and when working up the dead-reckoning the navigator must set down in the traverse table, as a regular compass course and distance sailed by the ship, *east, six miles.* The latitude and longitude of Sandy Hook light being accepted as a point of farewell, the opposite point to the bearing of the light and the distance from it must be considered as having been sailed; otherwise the ship would be six miles out in her dead-reckoning.

This course of *east* must be corrected for the deviation of the compass for the ship's head (if deviation exists), also for the variation of the compass given by the chart for the locality of the vessel; this will convert it into a true or geographical course. (See Corrected Course.)

DEVIATION.—(See Compass; Amplitude; Azimuth; Corrected Course.)

DIP.—A heavenly body is understood to dip when it disappears below the horizon. When a heavenly body crosses the meridian of the observer the limb of its image, as viewed in the

sextant-glass, will drop below the horizon line, and under such conditions it is said to dip. (See Dipping Needle.)

DIP OF THE HORIZON.—As the observer's eye is naturally above the sea-level, the limit of view is called the visible or apparent horizon, and the angle between this and the sensible horizon is called the dip of the horizon, which is further explained under the head of Corrected Altitude.

DIPPER.—The seven stars forming the constellation of the Great Bear, and by means of which the Pole Star, in the tail of the Little Bear, can be readily found.

DIPPING NEEDLE.—A magnetic needle suspended at its centre of gravity so as to move freely from the horizontal to the perpendicular. On the magnetic equator the needle assumes the horizontal, but at the magnetic poles it stands perpendicular or has a dip of 90°.

DISTANCE TABLES.—Tabulated distances at which objects can be seen at sea according to their respective elevations, combined with the height of the observer's eye above the sea-level. A distance table will be found in the back of this book. (See Danger-Angle Tables.)

DIURNAL.—Relating to the day.

DIURNAL ARC.—The half circle described by a heavenly body from its rising to its setting. (See Nocturnal Arc.)

DIVIDERS.—An instrument consisting of two pivoted legs, used by navigators for measuring distance on a chart, pricking off positions, etc.

DOMESTIC NAVIGATION.—Generally refers to inland sailing.

DOUBLE ALTITUDE PROBLEM. — (See Sumner's Method.)

DOUBLE STAR.—Two stars appearing so close together that they seem to touch.

D. R.—Letters employed to express the word dead-reckoning.

DRIFT.—When a ship is hove-to she will continually come up and fall off. The middle point between this coming up and falling off must be considered as her compass course, and the leeway, deviation, and variation applied to this compass course in order to obtain the true or geographical track of the ship.

Example.—A ship is hove-to on the starboard tack ; her head comes up to east and falls off to east-northeast; leeway, four points ; deviation of the compass, one point westerly; variation of the compass, one point westerly.

Now the middle point between east and east-northeast is east-by-north, and to this we apply the leeway, which gives us northeast-by-north. Next we apply the deviation and variation, and obtain for the true or geographical course of the ship north-by-east.

DRY COMPASS.—A compass card enclosed in an air-chamber, commonly referred to as a dry-card compass. (See Liquid Compass.)

DUMB COMPASS.—A circle of brass or other substance having engraved or printed on it the points of the compass.

EARTH.—The third planet in order of distance from the sun ; equatorial diameter, 7,926 miles ; polar diameter, 7,899 miles. The difference between the two diameters (twenty-seven miles) is called the compression. Surface, one hundred and ninety-seven millions of square statute miles, of which fifty-one millions is land ; mean distance from the sun, ninety-three millions

of miles ; circumference at the equator, about twenty-five thousand miles ; inclination to the plane of the ecliptic, 23½°.

EARTH'S INDUCTION.—(See Magnetic Induction.)

EIGHTY-NINE-FORTY-EIGHT. — In working latitude some navigators lump the correction for the lower limb of the sun as a constant plus 12′ quantity, and simply add this amount to their observed altitude in order to obtain the central altitude of the body. They then subtract the latter from 90°, as usual, to find the zenith distance. Others adopt a still shorter method for obtaining the zenith distance : instead of adding 12′ to their observed altitude they subtract the observed altitude from 89° 48′ (which is 12′ less than 90°), which at once gives the zenith distance. This twelve-minute or eighty-nine-forty-eight method is liable to make an error of several miles in the answer to the problem when the height of eye correction (dip) is large, such as it would be on the deck and bridge of a vessel with a high freeboard. Altitudes should always be corrected as explained under the head of Corrected Altitude.

ECLIPTIC.—The apparent path of the sun around the earth, but the earth's real path. (See Inclination.)

ELEVATED COMPASS.—A masthead or a pole compass raised above the deck for the purpose of getting it beyond the magnetic influence of the ship's iron and machinery.

ELEVATED POLE.—The pole which is above the horizon. The elevation of the pole is the altitude of the pole above the true horizon, and it is equal to the latitude of the place.

EPHEMERIS.—An unabridged astronomical almanac.

EPITOME.—An abridged treatise, such as an epitome of navigation.

EQUAL ALTITUDES.—(See Longitude.)

EQUATION OF TIME.—The difference between mean and apparent time. The equation of time selected from the Nautical Almanac for Greenwich noon of the given Greenwich date must always be corrected for the number of hours shown from Greenwich noon by the chronometer when the altitude of the heavenly body was measured.

Rule.—Select from the Nautical Almanac the equation of time for the given Greenwich noon, also the hourly difference of equation, and multiply the latter by the number of hours shown from Greenwich noon by the chronometer when the observation was taken; then either add this correction to or subtract it from the equation given for Greenwich noon, according as the equation of time is increasing or decreasing. The idea is to find the equation of time for the hour of observation. (See Mean Sun.)

EQUATOR.—The imaginary line encircling the earth, equidistant 90° from the north and south poles.

EQUINOCTIAL.—The celestial equator.

EQUINOCTIAL POINTS.—(See First Point of Aries.)

EQUINOX.—(See Autumnal Equinox; Vernal Equinox.)

ERROR OF COLLIMATION.—(See Axis of Collimation.)

EVENING STAR.—(See Morning Star.)

EX-MERIDIAN.—(See Latitude.)

FAREWELL.—(See Departure.)

FATHOM.—(Six feet.)

FINDING THE TIME.—(See Regulating.)

FIRST MERIDIAN.—(See Prime Meridian; Circumnavigator's Day.)

FIRST POINT OF ARIES.—That point of the ecliptic which the sun crosses on March 21st from the south to the north side of the equator. The point of the ecliptic which the sun crosses on September 23d from the north to the south side of the equator is known as the First Point of Libra. These two points are termed the Equinoctial Points, and when the sun crosses them the lengths of the days and nights are equal throughout the world. The First Point of Aries is the Spring (or Vernal) Equinox, and the First Point of Libra is the Autumnal Equinox.

FIRST POINT OF CANCER.—That point of the ecliptic which the sun enters about June 21st, when its declination is 23½° north.

FIRST POINT OF CAPRICORN.—That point of the ecliptic which the sun enters about December 21st, when its declination is 23½° south.

FIRST POINT OF LIBRA.—(See First Point of Aries.)

FIXED STARS.—The term "fixed stars" applies to those bodies in the heavens which appear constantly in the same relative position. The fixed stars shine by their own light, and their apparent twinkling and their smaller appearance distinguish them from the planets. The planets are seen sometimes in one position and sometimes in another, the same planet being at one time the morning star and at another time the evening star. The fixed stars are separated into classes, the brightest being stars of the first magnitude, of which it is generally accepted there are nineteen; the second in order of brightness are classed under the head of second magnitude and number about sixty; next

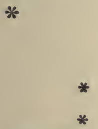
the third magnitude, numbering about two hundred ; then follow fourth, fifth, and sixth magnitudes, beyond which they cannot be distinguished without the aid of a telescope, consequently such stars are known as telescopic stars. Variable stars are those which appear to intermit in the way of brightness, and intermediate stars are those which are divided between two magnitudes, and may be seen expressed as 1–2, meaning that they are nearer 1 than 2 ; but if they are expressed as 2–1, it means that they are nearer 2 than 1. The term magnitude has no reference to the dimensions or masses of the stars, but only to their brightness. The word constellation means a group of stars, fancifully supposed to represent some figure, such as a classical hero, a beast, bird, fish, etc. The brightest stars were distinguished by the ancient astronomers by proper names, such as Rigel, Sirius, etc.; but the commonest practice is to use the small letters of the Greek and Roman alphabets to classify their degrees of brightness, α being prefixed to the brightest, β to the next brightest, and so on. When the Greek letters are exhausted the Roman are made use of, such as a, b, c, d, etc., and when these are also exhausted then numerals are made use of, such as 1, 2, 3, 4, etc.

The following nine stars (Arietis, Aldebaran, Pollux, Regulus, Spica, Antares, Aquilæ, Fomalhaut, and Pegasi) are those principally used by navigators for finding the longitude, and the navigator should not rest satisfied until he has succeeded in so familiarizing himself with those parts of the heavens in which they are placed as to be able to readily refer to them. By following the directions given he may soon impress their relative positions upon his memory.

In the higher northern latitudes if the observer will look toward the north pole he will see (as shown following) a star

of the second magnitude, called the Pole Star. It is easily recognized because it has no other star of equal brightness in its immediate vicinity, and because it is always seen in the same direction—bearing north. Another distinguishing feature in relation to it is the constellation of the Seven Stars, commonly known as the Dipper, the two stars in the dipper end of which (called the Pointers) point to the Pole Star.

α Arietis.



This star bears about west, distant 23° from the Seven Stars; it is of the second magnitude, and may be known by means of a star of the third magnitude, situated southwest from α Arietis, at the distance of 3½°. South from this star, at a distance of 1½°, is a star of the fourth magnitude.

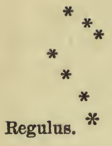
Aldebaran.

About 35° east-southeast from α Arietis, and 14° southeast from the Seven Stars, is the bright star Aldebaran. Near this star to the westward are several stars of the third and fourth magnitudes, forming with Aldebaran the letter V. At the distance of 23° from this star, in a southeast direction, are three very bright stars, situated in a straight line, near to each other, being known as The Belt of Orion.

Pollux.

At a distance of 45° from Aldebaran, in the direction of east-northeast, is the bright star Pollux. Northwest from Pollux, distant 5°, is the bright star Castor.

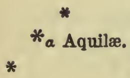
East-southeast-half-east from Pollux, at a distance of 37½°, is the bright star Regulus. North of



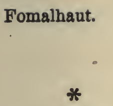
this star, at a distance of 8°, is a star of the second magnitude, and further to the northward are five stars of the third magnitude, the whole forming a cluster resembling a sickle, Regulus being the extremity of the handle. A line drawn from the Pole Star, through its pointers, will pass about 12° to the eastward of Regulus.

East-southeast from Regulus, at a distance of 54°, is the bright star Spica, with no other bright star near it. Southwest from this star, at a distance of about 16°, are five stars of the third and fourth magnitudes, situated as shown in adjoining figure, the two northernmost of which form a straight line with Spica.

East-southeast from Spica, at a distance of 46°, is the remarkable star Antares, being of a reddish color, so that it is easily distinguishable. On each side of it, about 2° distant, is to be found a star of the fourth magnitude, these stars bearing respectively from Antares west-northwest and south-southeast. In the vicinity of Antares there is no very bright star.



Northeast from Antares, at the distance of 60°, is the bright star α Aquilæ; north-northwest of which, at 2° distant, is a star of the third magnitude, and south-southeast, at 3° distant, is a star of the fourth magnitude. These three stars appear practically in a straight line. α Aquilæ may be readily distinguished, as it is of a reddish nature, being nearly of the same color as Antares.



Southeast from α Aquilæ, at a distance of 60°, is the bright star Fomalhaut. It is in high southern declination, so that in northern latitudes its altitude is small. On the parallel of 40° north its altitude is about 20°. Fomalhaut bears nearly south from the star α Pegasi, being about 45° distant. A line drawn from the pointers in the Dipper, through the Pole Star, and continued to the opposite meridian, will pass very near to α Pegasi and Fomalhaut.

East-by-north from α Aquilæ, at a distance of 48°, and westward from α Arietis, at a distance of 44°, is the star α Pegasi, which may be distinguished by means of four stars of varying magnitudes, situated as shown in the adjoining figure. The star due north of α Pegasi is of the second magnitude, and is distant 13°. The two close stars northwest of α Pegasi point to this star, and the most northern one of the two close stars is in line with α Pegasi and the most northern and western star in the group.

Remarks.—To reconcile compass directions with the foregoing star diagrams, the navigator must hold the page upside down over his head, directing the top of the page toward the north.

FOCAL DISTANCE.—The distance between the object-glass and the image. Focal length means the same as focal distance.

FOUR-POINT BEARING.—(See Chart Sailing.)

FURLONG.—An eighth of a mile ; = forty rods ; = two hundred and twenty yards ; = six hundred and sixty feet.

GAINED DAY.—(See Circumnavigator's Day.)

GEOGRAPHICAL MILE.—A nautical or sea mile of 6,082.66 feet; the mean length of a minute of latitude; a knot.

GEOGRAPHICAL POLES.—The extremities of the earth's axis; the two points of 90° north and south.

GRADUATED.—Divided; a scale, as, for instance, the graduated arc of a quadrant, octant, and sextant, or a graduated vernier.

GRADUATED RULES.—Parallel rules having one of the bevelled edges divided into degrees and the other edge divided into quarter points of the compass. They are used for shaping a course and are independent of the diagram compasses on the chart.

Rule.—Lay the rules on the chart on the course to be determined so that the centre mark of the rules rests on a meridian line, and read the *true* course on the divided edge where it is cut by the meridian line. This true course must always have the variation of the compass for the ship's locality applied to it in order to convert it into a correct magnetic course; and provided deviation of the compass exists, this quantity must also be taken into consideration. (See Chart Sailing.)

GREAT-CIRCLE CHART.—(See Chart.)

GREAT-CIRCLE SAILING.—A straight course between two places is the arc of a great circle. A great-circle track drawn on a Mercator's chart represents a curve, except on the meridians and on the equator, which are great-circle tracks of themselves. According to a great-circle track plotted on a Mercator's chart a ship in following it would constantly change the direction of her head, but in reality she would sail in a

straight line. This is to be explained by stating that a Mercator's chart gives a distorted view of the earth's surface.

When a vessel, as in the case of a steamship, is navigated on a straight-line course on a Mercator's chart her head is never pointed in the exact direction of the port to which she is bound until that port heaves into sight; but when following a great-circle track her head is from first to last pointed direct for her destined port. In other words, when a vessel is navigated on a straight-line course on a Mercator's chart, her head at starting points toward the equatorial side of the port bound to, and gradually, as the voyage progresses, her head turns in the right direction, or toward the point of her destination; whereas the great-circle track leads direct from one port to the other.

As well as shortening the distance between two places, the great-circle track is of the highest importance for sailing ships, as it often happens that a more or less head wind according to a Mercator's course is made a fair wind on a great-circle course. The real direction of the port bound to can only be ascertained by consulting the great circle, and this determines whether the existing wind is fair or ahead for the great-circle course.

To illustrate the foregoing theory the author shows the following example, given by Captain S. T. S. Lecky, in his masterly digest of navigation entitled "Wrinkles." It proves the possibilities of the great-circle track for sailing vessels:

Example.—"Take, for instance, the case of a vessel bound from Quebec to Greenock or Liverpool. The true course and distance by Mercator's chart from Belleisle Light-house to Inishtrahul Light-house is N. 83° E., 1,722 miles; but the distance on the great circle is 1,690 miles, or thirty-two miles less; whilst the course at starting is N. 63½° E., or 19½° more to the northward. Now if a sailing ship on clearing the Strait has the wind

at east-half-north, it would at first seem immaterial on looking at Mercator's chart which tack she was put upon ; but if placed on the starboard tack she would lie up within $3\frac{1}{4}$ points of the true direction of her port, whilst if placed on the other tack, instead of approaching her port she would be actually going away from it."

To Draw the Great-Circle Track.—Professor Airy's exceedingly simple and valuable table for sweeping an arc of a great circle on a Mercator's chart on one side of the equator is given following, and is heartily indorsed by the author of this volume.

Join the place of the ship and the place of destination by a straight line and find the middle point.

Draw from this middle point a perpendicular line toward the equator and continue the line beyond the equator if found necessary in order to sweep the arc.

With the middle latitude between the two places enter the following table and take out the "corresponding parallel."

The resting-point for the sharp leg of the pencil-point dividers will be the intersection of the corresponding parallel with the perpendicular line. Place the sharp point of the dividers in this intersection, then with the pencil leg of the instrument sweep an arc that will pass through the place of the ship and the place of destination, and this curved line will be the great-circle track required.

Changing the Course.—Except on the meridians and on the equator a ship must frequently change her course in order to keep to the great circle. Several points on the arc of the great circle are fixed upon, and these are made successively by the ship, the course being changed with each point arrived at. These courses will be shaped as usual by the parallel rules and the diagram compasses on the chart, so that in reality a series of

Middle Latitude.	Corresponding Parallel. Opposite Name to Latitude of Places.	Middle Latitude.	Corresponding Parallel. Same Name as Latitude of Places.
20°	81° 13′	*	*
22°	78° 16′	*	*
24°	74° 59′	*	*
26°	71° 26′	*	*
28°	67° 38′	58°	4° 00′
30°	63° 37′	60°	9° 15′
32°	59° 25′	62°	14° 32′
34°	55° 05′	64°	19° 50′
36°	50° 36′	66°	25° 09′
38°	46° 00′	68°	30° 30′
40°	41° 18′	70°	35° 52′
42°	36° 31′	72°	41° 14′
44°	31° 38′	74°	46° 37′
46°	26° 42′	76°	52° 01′
48°	21° 42′	78°	57° 25′
50°	16° 39′	80°	62° 51′
52°	11° 33′	*	*
54°	6° 24′	*	*
56°	1° 13′	*	*

rhumb lines are employed by the navigator to enable him to keep his ship approximately on the great circle.

The sum of the distances sailed on these short courses will not differ much from the distance found for the great circle, provided the points are not too widely spaced. A very practical method employed is to find the change of course in points of the compass from the starting-place to the middle point on the arc of the great circle, then to turn this number of points

into quarters, and divide the distance of half the circle by the number of quarter points so obtained, which will give the number of miles to sail on each quarter point.

Example.—Suppose that between the starting-point of the great circle and the middle part of same the change of course is two compass points, and that half of the entire length of the great-circle track is 1,000 miles. Now in two points there are eight quarters, so we divide 1,000 by 8 and get 125 for an answer ; consequently we should change the course a quarter of a point for each 125 miles sailed.

The navigator should bear in mind that the deviation of the compass must be considered in shaping the various courses on the great-circle track.

Measuring the Distance.—Turn the largest course on the great circle (which will be one of the ends of the arc) into degrees, and proceed as follows : Select the logarithms, cosecant of the largest course angle, cosine of the smallest latitude, and the sine of the difference of longitude between the two places ; add these three logs together, reject ten in the index, and the result will be the sine of the distance—the degrees of which will be multiplied by 60 to reduce them to miles, and the minutes of the angle added in, and the result will be the distance on the great circle.

When an angle exceeds 90°, its supplement (what it lacks of 180°) may be used, but in this case the sine of the distance should be subtracted from 180°, and the answer multiplied by 60 to obtain the distance.

Examples.—In the first consideration, with a course of 80° 30′, a latitude of 40° 30′, and a difference of longitude of 60° 23′, we would obtain a distance of 2,525 miles.

In the second consideration, with a course of 55° 57′, a lati-

tude of 6° 48′, and a difference of longitude of 140° 11′, we would obtain a distance of 7,793 miles.

Remarks.—By mere inspection it is possible to at once determine if a great-circle route is practicable—that land, ice, etc., will not interfere.

Great-circle sailing is valuable only in latitudes beyond the tropics, as within them (23° N. to 23° S.) the difference between the great circle and Mercator's tracks is too small to be considered—within a few degrees of the equator all straight lines drawn on a Mercator's chart practically represent great-circle tracks.

What is known as Mixed or Composite tracks are modifications of the great-circle track, adopted by reason of obstacles in the way of the latter, such as land, etc.

When driven a considerable distance from the great-circle track, the navigator should not attempt to regain it, but should trace a new great circle from the place of the ship.

GREENWICH DATE.—The day of the month at Greenwich. If at any time there should be uncertainty concerning the Greenwich date it may be determined as follows:

Express the ship's time astronomically (see Astronomical Time), then turn the ship's longitude into time (see Table 7, or Arithmetic of Navigation), and proceed according to one of the two rules given below:

West Longitude.—Add the longitude in time to the ship's astronomical time: their sum, if less than twenty-four hours, will be the Greenwich time of the same date as at ship; but if their sum is greater than twenty-four hours, reject twenty-four hours and put the Greenwich date one forward.

East Longitude.—If the longitude in time is less than the ship's astronomical time, subtract the former from the latter,

and call the Greenwich date the same as the ship's date; but if the longitude in time is greater than the ship's astronomical time, add twenty-four hours to the latter, then subtract, and call the Greenwich date one day less than the ship's date.

GREENWICH TIME.—The Greenwich hour shown by a chronometer set to that meridian. If the ship's longitude is turned into time (see Table 7, or Arithmetic of Navigation) and added to the local time at the vessel (as shown by the ship's clock), when in west longitude, but subtracted from the local time at ship when in east longitude, the answer will be the Greenwich time, independent of the chronometer.

GROUND LOG.—An instrument for detecting the presence of a current when the ship is becalmed on soundings out of sight of land. An ordinary heaving lead is made fast to the regular chip log-line, then the lead is cast overboard and allowed to rest on the bottom. If there is a current, the drift of the ship from the lead will at once give its direction by the angle of the log-line, and the velocity of the current will be measured by the seconds glass, or watch, as explained under the heading of Chip Log.

GUNTER'S SCALE.—A flat rule about two feet in length, marked on one side with the scales of equal parts, chords, tangents, sines, etc., and on the other side with the logarithms of these parts. It is employed for solving mechanically certain problems in navigation and surveying.

HACK WATCH.—A common watch used by navigators, who set it to the time shown by the chronometer, so as to carry the Greenwich time with them on deck when about to measure an altitude. It is also set to the apparent time at ship when ob-

serving azimuth bearings of the sun for determining the deviation of the compass.

HEAVE OF THE SEA.—When a vessel is sailing more or less in the trough of a heavy sea, the effect is to drive her to leeward, and this is expressed either as the heave of the sea or send of the sea. It goes without saying that a shallow vessel will be lifted off more than a deep vessel, and for that reason no rule can be given, the navigator being obliged from experience to estimate the quantity for his vessel.

HEELING ERROR.—The change of compass deviation owing to the vessel being listed to port or starboard, and which is compensated by a vertical steel magnet placed exactly under the centre of the compass card. Heeling error will be at its maximum when the vessel is heading north or south, as the north end of the needle will be drawn to the elevated (weather) side.

HIGH LATITUDES.—Parallels far removed from the equator, both in the northern and southern hemispheres. Opposed to low latitudes, which are parallels in the vicinity of the equator.

HORIZON.—The apparent meeting of the sea and sky. (See Artificial Horizon; Dip of the Horizon; Sensible Horizon; Visible Horizon.)

HORIZON GLASS.—(See Sextant.)

HORIZONTAL DANGER ANGLE.—(See Chart Sailing.)

HORIZONTAL PARALLAX.—When a heavenly body is on the horizon of the observer, its altitude to him is practically zero, but another observer viewing the body at the same time from the centre of the earth would not see it on his horizon, but elevated above it; and the difference between these two angles is called the horizontal parallax.

HOUR ANGLE.—The angle of a heavenly body at the pole, between the observer's meridian and the circle of declination passing through the body. This angle is measured on an arc of the equinoctial intercepted between the meridian and the circle of declination, and is converted into time by giving to every fifteen degrees (15°) a value of one hour.

HURRICANE.—(See Law of Storms.)

HYDROGRAPHIC CHART.—(See Chart.)

HYGROMETER. — A wet-bulb thermometer employed by navigators as an adjunct to the barometer and dry-bulb thermometer in foretelling weather. This instrument is used to measure the amount of moisture in the air. Two equal thermometers are selected and mounted on the same frame, the bulb of one being left naked, while the other is tied up in a thin muslin covering with a cotton wick leading from it to a small cup of water placed beneath it and about three inches away from the wet-bulb thermometer. As the evaporation of the water produces cold, the mercury in the wet-bulb tube will stand lower than its companion the dry bulb, and the depression of the wet-bulb thermometer measures the humidity of the atmosphere. If the water in the muslin which covers the wet bulb be frozen, it will not affect the record, but will give the same reading as though frost did not exist.

In frosty weather, to insure against the muslin becoming dry through evaporation, it should be wetted and allowed some little time to freeze before the reading is made.

The muslin and wick should so act as to keep the wet bulb always wet so that evaporation may be constantly going on; and it is recommended that the little muslin bag and wick be

changed about once a month owing to their tendency to become foul with grit and smoke and dust.

When rain, fog, or dew is promised the hygrometer will rise.

HYPOTHENUSE.—The longest side of a right-angle triangle, or the line opposite the right angle. (See Base ; Perpendicular.)

INCIDENCE.—In the artificial horizon the image of a body is reflected from the surface of the quicksilver to the eye, and the measured angle is always divided by 2 in order to obtain the altitude. This proves at once that the angle of incidence is equal to the angle of reflection. The angle from the body to the quicksilver is the angle of incidence, and the angle from the quicksilver to the eye is the angle of reflection.

INCLINATION.—The inclination of the plane of the earth's equator to the plane of the ecliptic is about 23° 28′ ; this it is that accounts for the declination of the sun. If the axis of the earth was perpendicular to the plane of the ecliptic, the sun would always be on the equator, and in that case the corrected altitude subtracted from 90° would always be the latitude of the observer as well as the zenith distance of the sun.

INDEX.—The integer part of a logarithm. (See Sextant.)

INDEX BAR.—(See Sextant.)

INDEX ERROR.—(See Sextant.)

INDEX GLASS.—(See Sextant.)

INDUCTION.—(See Magnetic Induction.)

INSTRUMENTAL PARALLAX.—A sextant should always be adjusted by the horizon line at sea and by a distant line (such as the roof of a remote building) on shore, because the horizon and index glasses of the sextant are not on the same horizontal

plane. When the horizontal line of a near object is used the sextant cannot be properly adjusted ; but when the horizontal line of a distant object is employed, the instrumental error is practically eliminated.

INTERCALARY DAY.—A day that is inserted in the calendar out of the common order so as to preserve the correspondence between the civil and the solar year. The 29th of February in a leap year is an intercalary day.

INTERCARDINAL POINTS.—Northeast, southeast, southwest and northwest points of the compass.

INTERPOLATION.—To alter by inserting something, as, for instance, reducing the given declination of a heavenly body to another time than that for which it is originally recorded.

INTERTROPICS.—Between the tropics ; between the parallels of 23½° north and 23½° south.

INVERTING TELESCOPE.—(See Sextant.)

IRRADIATION.—The apparent enlargement of the diameters of the sun and moon. It is an optical illusion caused by the light of the object, and may be best appreciated in the illustration of the new moon—the bright crescent appearing to be a part of a larger circle than that of its shadowed disk. Irradiation increases with the brightness of the object, and diminishes in proportion as the illumination of the body and that of the field of view approach equality, vanishing when they become equal. This apparent augmentation is greatest in the case of the sun ; but even in reference to this body the amount of irradiation seldom exceeds 6″, so that for all practical purposes the question need not be entertained by the navigator.

KISS.—When the image of the moon's or sun's limb is made

to touch the horizon line in measuring an altitude, it is said to *kiss* the horizon.

KNOT.—(See Mile.)

LANDFALL.—To first make the land, to obtain the first view of land when coming from sea. To make what is known as a good landfall signifies that the navigation of the ship has been well performed, and that the exact point of land discovered is the place previously calculated on by the navigator.

LATITUDE.—The distance of a place on the earth's surface north or south of the equator. Latitude is measured from the equator in degrees, minutes, and seconds. In a degree of latitude there are sixty geographical or nautical miles or minutes, each possessing a value of 6,082.66 feet. A mile of latitude and a minute of latitude mean the same thing. The extremities of the earth's axis, the north and south poles, have a value of 90°. Latitude may be said to be the angular distance of a place from the equator, measured on a meridian. The following rules furnish the methods for finding the latitude of the ship by observations of the sun, moon, planets, and stars:

Latitude by the Sun at Meridian.—Observe the altitude (see Altitude) and note the Greenwich hour shown by chronometer; then correct the observed altitude for index error (if any), semidiameter, parallax, dip, and refraction (see Corrected Altitude), and always subtract the answer, called the true central altitude, from 90° to obtain the zenith distance, which name the opposite to the bearing of the sun at meridian—*i.e.*, north or south. Correct the sun's declination (see Declination), and if the corrected declination has the same name (north or south) as the zenith distance, add the two quantities; but if they are of different names, subtract the less from the greater, and the an-

swer will be the latitude, which will take the name of the greater quantity.

Latitude by the Sun—Ex-Meridian.—It sometimes happens that when the sun has climbed almost to the meridian a passing cloud obscures it and that the body fails to reappear in time for its meridian altitude to be measured, or, on the other hand, there are cloudy days when the sun does not appear in the morning, but bursts through the clouds, temporarily or permanently, some little time after meridian. Bowditch gives two very useful tables by which the variation of the sun's altitude may be found for thirteen minutes of time on each side of the meridian, which tables are employed according to the following rule:

Rule.—Observe an altitude (see Altitude) and note the Greenwich hour shown by chronometer, then reduce this mean time to the apparent time at Greenwich by applying the equation of time. Next turn the ship's longitude into time and subtract it if west but add it if east and the answer will be the apparent time at ship. Now with this time from ship's noon enter Table 27 and select the figures given. Next with the latitude by dead-reckoning to the nearest degree and the sun's declination to the nearest degree, enter Table 26 and find the figures by which the figures taken from Table 27 must be multiplied. The answer will represent the change of altitude in seconds of arc for the given time from noon, and this result will be divided by 60 to convert it into minutes of arc; then this is *always added* to the observed altitude, whether the angle was measured before or after meridian, for in either case the sun was lower than it was at noon. Now correct this augmented altitude for semidiameter, etc., and proceed precisely the same as described in the preceding rule for a regular meridian sight.

Wrong

Remarks.—When the time from noon exceeds the limits of Table 27 (13 minutes), the augmentation of the altitude may be found by simply calculating the square of the given number of minutes, then multiplying same as usual by the figures from Table 26.

Examples.—If the time from noon is 20 minutes, take out from Table 27 the square for 10 minutes, which is 100; multiply this by 4 and the answer will be 400—the square of 20 minutes. Now multiply this 400 by the quantity given in Table 26 for the ship's latitude and the sun's declination, and the answer will be the required correction to be added to the observed altitude.

If the time from noon is 14 minutes, take out the square of 7 minutes, which is 49; multiply it by 4, and the answer will be 196, the square of 14 minutes, which will be multiplied by the figures from Table 26.

If the time from noon is 17 minutes, take out the square of 8 minutes and 30 seconds, which is 72.2, and multiply it by 4, and the answer will be 288.8, which will be multiplied by the figures from Table 26.

Explanation.—The square of the minutes from noon may also be found in the following easy manner, independent of Table 27:

If the time from noon is 32 minutes, the required square will be found by multiplying 32 by its own number, hence 32 multiplied by 32 equals 1,024 ($32 \times 32 = 1,024$), which will be multiplied as usual by the figures from Table 26.

It must be remembered in using the method of ex-meridian that when the sun passes near the zenith (that is, when its altitude is high) the time from noon at which the observation is taken must not exceed the figures in Table 27.

The navigator must bear in mind that the latitude found by an

ex-meridian observation is the latitude of the ship at the exact time of the sight, and not at 12 o'clock (meridian). To carry this latitude forward or back to noon, it is necessary to apply to it the difference of latitude selected from the Table (1 or 2) for the course and distance made by the ship in the interval between the time of sight and noon.

Latitude by the Moon at Meridian.—Observe the altitude (see Altitude) and note the Greenwich hour shown by chronometer. Correct the latter for its rate (see Rate), also the altitude for index-error (if any), semi-diameter, dip, parallax, and refraction (see Corrected Altitude). Always subtract the answer, called the true central altitude, from 90° to obtain the zenith distance, naming the latter the opposite to the bearing of the moon at meridian—*i.e.*, north or south. Correct the moon's declination (see Declination), and if the corrected declination has the same name (north or south) as the zenith distance, add the two quantities, but if they are of different names, subtract the less from the greater, and the answer will be the latitude, which will take the name of the greater quantity.

Latitude by a Planet at Meridian.—Observe the altitude (see Altitude) and note the Greenwich hour shown by chronometer. Correct the altitude for index error (if any), dip, parallax, and refraction (see Corrected Altitude), and always subtract the answer, called the true altitude, from 90° to obtain the zenith distance, naming the latter the opposite to the bearing of the planet at meridian—*i.e.*, north or south. Correct the planet's declination (see Declination), and if the corrected declination has the same name (north and south) as the zenith distance, add the two quantities, but if they are of different names subtract the less from the greater, and the answer will be the latitude, which will take the name of the greater quantity.

Latitude by a Star at Meridian.—As the stars are passing the meridian at all hours of the night, it becomes a very simple problem to determine the latitude of the ship when the sky is clear and when the horizon is outlined. In the back of this book will be found star tables which include all the stars of the first magnitude both in the northern and southern hemispheres, and the navigation stars of the second and third magnitudes, together with the astronomical apparent times that they cross the observer's meridian on the first day of each month throughout the year, also their rough declinations. As the times given in the tables for the meridian passages of the stars are calculated astronomically, it must be remembered that from 1 to 12 the hours agree with P.M. civil apparent time, but 13 hours means 1 o'clock in the morning, 14 hours means 2 A.M., 20 hours means 8 A.M., etc. The declinations of the stars are practically constant, and do not require correction, but the small annual changes of declination are shown in the almanac.

The stars come to the meridian four minutes earlier on each successive day, therefore to find the time of a star's meridian passage for any day between the first and last of the month, multiply by 4 the number of days that have passed since the first of the month and always subtract this sum from the time of the meridian passage given for the first. For example suppose that it was required to know the time of the meridian passage of the star Sirius on the 10th of January. The difference between 1 and 10 is 9, so we multiply the latter by 4, and receive 36 for an answer, and this we subtract from the time given for the star's meridian passage on the 1st of January (11 h. 50 m.) and obtain 11 h. 14 m., which represents the time that Sirius will cross the meridian of the ship on the 10th day of

January. Proceed to find the latitude in the following manner:

Rule.—Observe the altitude (see Altitude) and correct same for index error (if any), dip, and refraction (see Corrected Altitude), then always subtract the answer, called the true altitude, from 90° to obtain the zenith distance, and name the latter the opposite to the bearing of the star at meridian—*i.e.*, north or south. Now set the star's declination (given in the almanac) under the zenith distance, and if they are of the same name (north or south) add the two quantities, but if they are of different names, subtract the less from the greater, and the answer will be the latitude, which will take the name of the greater quantity.

Remarks.—This star method is the shortest and simplest of all latitude calculations.

Whenever it is possible the navigator should observe stars both north and south of him (north and south of his zenith), then take the mean of the two latitudes obtained, as this will eliminate or halve possible errors in the way of misjudging the horizon, etc.

Should the navigator require the time of the meridian passage of a star not contained in either of the star tables in this book, he may calculate it readily by the following method:

First, select the star's right ascension for the given day from the star page in the back of the Nautical Almanac, also the sun's right ascension from the almanac for the given day of the month.

Second, if the star's right ascension is less than the sun's right ascension add twenty-four hours to the former, but if not then let it stand as selected. Now subtract the sun's right ascension from the star's right ascension, and the answer will be the astronomical apparent time of the star's meridian passage.

Latitude by the Pole Star at Any Hour.—The following

rule for finding the latitude at any hour of the night by the Pole Star when it is out of the meridian is, to a certain extent, unsatisfactory, inasmuch as it cannot be depended upon to give the ship's position within two or three miles, although oftentimes with a good horizon the results are quite correct.

Rule.—Observe an altitude (see Altitude) at any hour when the star can be seen, and correct the altitude for index error (if any), dip, and refraction (see Corrected Altitude); the answer will be the true altitude. To the time shown by the ship's clock when the observation was taken add four minutes for every degree of longitude sailed east since the clock was last set, but subtract four minutes for every degree sailed west. Turn this corrected local apparent time into astronomical time by simply counting the hours from noon to noon in numerical order (1 to 24), instead of dividing them into A.M. and P.M. (see Astronomical Time). To the astronomical time at the ship always add the sun's right ascension from the Nautical Almanac for the given day, and if the result exceeds twenty-four hours then subtract twenty-four hours and apply the remainder (which is called the right ascension of the meridian) in the Pole Star table in the back of this book, and opposite the hours and minutes will be found a correction which will either be added to or subtracted from the true altitude, according to the given sign; if + add, if − subtract. The answer will be the latitude, always north, as the star cannot be seen south of the equator.

Latitude by a Meridian Altitude Below the Pole.—In high latitudes when observing a meridian altitude of a body below the pole the altitude will grow less and less until the lowest part of the circle is reached, at which point the body will cross the meridian below the pole, after which it will commence to rise.

To find the latitude by a body when it crosses the meridian below the pole, correct the altitude as usual, then obtain the polar distance by subtracting the body's corrected declination from 90°. Now add together the polar distance and the true altitude, and the result will be the latitude.

Latitude by Dead-Reckoning.—(See Dead-Reckoning.)

Latitude by the Artificial Horizon.—(See Artificial Horizon.)

LAW OF STORMS.—When a regular wind is so obstructed as to produce a hurricane the wind assumes a rotary motion and extends over an area of from thirty to several hundreds of miles in diameter, revolving with greatest velocity near the vortex. The centre, however, of a hurricane is a space of calm in which frightful and confused seas are to be experienced. In the northern hemisphere these winds revolve contrary to the movements of the hands of a clock, and in the southern hemisphere they revolve in the same direction as the hands of a clock. The course or track followed by a hurricane is tolerably definite, as will be seen by the following:

Track in the Northern Hemisphere.—The cyclone has its origin between the parallels of 10° and 18° north, and advances, or rolls forward, in a general northwesterly direction. Between the parallels of 25° and 30° it recurves and advances in a general northeasterly direction. From the start and until it breaks up the hurricane spreads out, or increases its diameter, while the wind, to some extent, decreases as the area of the storm widens. West India hurricanes, as a rule, range between the parallels of 10° and 50° north and the meridians of 55° and 85° west, their average rate of progression being three hundred miles a day.

Track in the Southern Hemisphere.—The cyclone has its origin in the equatorial regions (rarely within 6° of the equator)

and advances, or rolls forward, in a general southwesterly direction, and somewhere about the parallel of 25° south it recurves and advances in a general southeasterly direction, increasing in diameter from the start, and finally breaks up.

Barometer and Weather Indications.—The barometer often rises suddenly just in front of a storm, owing to the air banking up there; consequently if the general appearance of the weather indicates a storm the rise of the barometer is not to be accepted as evidence that a storm will not be experienced, but rather that one is at hand. The approach of a cyclone may often be foretold by a greenish-tinted sky, a blood-red or bright yellow sunset, a heavy, unaccountable wave-swell, or a thick, lurid appearance of the atmosphere. A restless state of the barometer is another warning. After the ship has entered the storm disk, if a rapid fall of the barometer is experienced it may be accepted as evidence of a violent storm of small diameter; but if a gradual fall of the barometer is noted, then the opposite conditions may be counted on.

Distance of the Storm Centre.—The following table is given to show the approximate distance that has been calculated for the centre of the cyclone, according to the average fall of the barometer per hour. It is a rough calculation, but it has a certain value:

Average Fall of Barometer per Hour.	Distance in Miles from Storm Centre.
From 0.02 in. to 0.06 in.	From 250 to 150.
" 0.06 " 0.08 "	" 150 " 100.
" 0.08 " 0.12 "	" 100 " 80.
" 0.12 " 0.15 "	" 80 " 50.

Practical Considerations.—The revolving-storm problem, when considered practically as regards the safe navigation of the ship, is simple. First, locate the centre of the cyclone; second, ascertain the semicircle in which the ship is; third, determine the direction in which the storm is moving, and decide upon what course to pursue.

Bearing of the Storm Centre.—Face the wind and note its bearing by compass, then, in north latitudes, count eight points (90°) to the right; but in south latitudes count eight points to the left of the wind's eye. If the navigator in the northern hemisphere has the wind at east, the centre of the cyclone will bear south of him. If a navigator in the southern hemisphere has the wind at east, the centre of the cyclone will bear north of him.

Semicircles of Storm-Disk.—The storm-disk being divided into two equal parts by the line or axis of the storm track, these two semicircles are named according to the following: Look in the direction toward which the storm is moving, then the portion that lies on the right side of this line is known as the right semicircle, and the portion that lies on the left side is known as the left semicircle. In the right semicircle the wind changes to the right—from north toward east, from east toward south, from south toward west, and from west toward north; but in the left semicircle the wind changes to the left—from north toward west, from west toward south, from south toward east, and from east toward north. The first change of wind will prove to the navigator the semicircle he is in.

To Avoid the Centre.—In the northern hemisphere, if the ship is in the right semicircle, haul by the wind on the starboard tack and keep going as long as possible; but if the ship is in the left semicircle, bring the wind on the starboard quarter,

note the compass course when the ship is so headed, and keep to that course. In the southern hemisphere, if the ship is in the right semicircle, bring the wind on the port quarter, note the direction of the ship's head by compass, and keep to that course; but if the ship is in the left semicircle, haul by the wind on the port tack, and keep going as long as possible.

Tack to Heave-to On.—If obliged to heave-to, act according to the following simple rule: If in the right semicircle, heave-to on the starboard tack; but if in the left semicircle, heave-to on the port tack. This rule applies to all parts of the world, and should be impressed upon the navigator's memory.

On the Storm-Track.—When the ship is on the storm track in front of the centre, she will not experience a change of wind, but will have a falling barometer and constantly increasing severity of weather; but if in the rear of the storm-centre, she will have a rising barometer and a gradual moderation of the weather. In the northern hemisphere, if in front of the centre, put the ship before the wind, note the compass course when the ship is so headed, and keep to that course, and if obliged to heave-to do so on the port tack, but if in the rear of the centre, run out with the wind on the starboard quarter, or heave-to on the starboard tack. In the southern hemisphere, if in front of the centre, put the ship before the wind, note the compass course when the ship is so headed and keep to that course, and if obliged to heave-to do so on the starboard tack; but if in the rear of the centre, run out with the wind on the port quarter, or heave-to on the port tack.

Remarks.—When, according to the foregoing rules, a ship is laid-to on the port tack in the left semicircle in the northern hemisphere, and on the starboard tack in the right semicircle in

the southern hemisphere, her head will be directed toward the storm centre. There will be no danger in this, however, as the ship will not head-reach to any extent, consequently she will not approach the storm centre sufficient to amount to anything. Laid-to in this way, she will come up and bow the sea as the wind shifts, whereas if she was laid-to on the opposite tack she would be headed off with every shift of wind, and would ultimately bring the sea on the beam and quarter, and would probably founder.

It has been computed that West Indian cyclones, commencing with a very small diameter, increase the same to six hundred and one thousand miles before breaking up. In the Indian Ocean they spread out from one hundred to six hundred miles, and in the China Sea from eighty to four hundred miles.

The progressive rate of the West Indian hurricane or cyclone is about three hundred miles a day, and the rate of the Bay of Bengal and China Sea cyclones, two hundred miles a day ; but the rate of the Indian Ocean cyclone varies from fifty to two hundred miles a day.

The cyclone season for the West Indies, Atlantic Coast of America, and the coasts of Mexico and Lower California is from July to October. The cyclone season for the Malabar Coast and Bay of Bengal embraces the five months of April and May, October, November, and December. The cyclone season for the China Sea extends from July to November. The cyclone season on the coast of Japan takes in August, September, and October.

LEEWAY.—The sideways drift of a vessel through the water owing to the pressure of the wind on her spars, sails, and side. Running free, a vessel makes no leeway, as all the wind and wave force exerted is on the line of her course ; but the

closer the ship is hauled to the wind the more she will be forced to leeward. When a steam vessel makes leeway owing to a heavy beam wind and sea, it is recorded in the log-book under the head of "Send of the Sea." The manner of determining the amount of leeway being made by a vessel is extremely simple: It is only necessary to note the line of the keel by observing the course of the ship, then to see what angle the wake makes with this, and that will give at once the amount of leeway being made.

Example.—A vessel, we will say, is heading east on the starboard tack; the heel of her keel is west; the wake bears by compass west-by-south, consequently the wake makes an angle of one point with the line of the keel, which amount (one point) is the leeway being made. Under these circumstances the ship is really making an east-by-north course.

Remarks.—If a patent log is being towed, the angle made by the line as compared with the keel will give the amount of leeway.

Some vessels have a graduated half-circle of brass tacked on the middle of the taffrail, and when desiring to ascertain the amount of leeway, either by day or night, the bight of the log-line is carried to this half-circle and held in the rear centre, then the angle made by the line with the zero point of the circle will give the answer either in degrees or quarter points of the compass according as the circle is graduated.

In case the vessel is not towing a log, the hand-lead may be temporarily thrown overboard and allowed to trail astern, and the angle measured by it, as already explained.

When the vessel is making no leeway, the wake will be left dead astern, but if leeway is being made, the wake will trend away on the weather quarter. (See Corrected Course.)

LEAGUE.—A league is generally conceded to have a value of three nautical miles, but it varies in different countries. In the United States, France, Italy, and England, a league contains 6,075 yards; Spain, 7,416 yards; Holland and Germany, 8,100 yards; Russia, 8,468 yards.

LENS.—A piece of glass formed so as to change the direction of rays of light when passing through it, as the magnifying glasses used in telescopes.

LIMB.—(See Upper Limb.)

LINE.—A name for the equator.

LINE OF COLLIMATION.—Same as axis of collimation.

LINE OF NO VARIATION.—(See Compass.)

LIQUID COMPASS.—A compass card enclosed and entirely submerged in a chamber of alcohol and water or refined petroleum, to give steadiness to the card and to prevent it from flying about in a manner peculiar to a dry-card compass when sailing in rough water.

LOCAL ATTRACTION.—(See Compass.)

LOCAL APPARENT TIME.—Time calculated by the passage of the sun over the observer's meridian. The length of a solar day varies according to the sun's movement. (See Noon.)

LOCAL MEAN TIME.—Time calculated by the imaginary passage of an imaginary sun over the observer's meridian. This is known as the mean sun, and is adopted so as to give the civil day a value of exactly twenty-four hours. (See Mean Sun.)

LOCAL TRANSIT.—The passage of a heavenly body over the meridian of the observer.

LOG.—To make a memorandum of anything in the log-book is to "log" it. (See Chip Log; Log-Book; Patent Log.)

LOGARITHM.—A logarithm may be defined as the exponent of the power to which a given number, known as a base, must be raised in order to produce a certain number. By the employment of logarithms difficult and tedious problems in navigation are so simplified as to be calculated by men whose knowledge of arithmetic does not extend beyond the four common rules of addition, subtraction, multiplication, and division. (Table 44.)

To Select Logarithms for Degrees and Minutes.—The given number of degrees will be found at the bottom of the page when between 45° and 135°, otherwise at the top. The minutes of the angle must be found in that column marked M, which stands on the side of the page on which the degrees were found. If the degrees are found at the top of page, the sine, cosine, etc., must be read from the top, but if the degrees are found at the bottom of page, then the sine, cosine, etc., must be read from the bottom. Opposite the given number of minutes will be found the required logarithm.

To Select Proportions for Seconds.—The proportional parts will be found by the columns of differences for seconds. The correction of the logarithm for any number of seconds is found by entering the left-hand column of the table marked M' at the top, and finding the number of seconds in the regular minute column, and opposite to this in the column of differences will be found the corresponding correction. Thus on the page which contains the log. sines, tangents, etc., for 30°, the corrections for 25″ are 9 for the columns A. A.; 12 for the columns B.B., and 3 for the columns C.C.; so that if it were required to find the sine, tangent, or secant of 30° 12′ 25″ we would add these corrections respectively to the logarithms corresponding to 30° 12′, because these logarithms increase in proceeding from 30° 12′ to

30° 13′. If the logarithms decreased from 30° 12′ to 30° 13′, we would subtract this correction.

To Correct Time for Proportions of Logarithms.—In working a chronometer sight, when selecting the time for the logarithm called "sine of apparent time at ship," if it is impossible to match the logarithm in the column of sine, take the nearest logarithm to it, calculate the difference between the two by simple subtraction, and note the alphabetical sign (A.B. or C.) belonging to the column; then apply this difference in the little table of correction at the foot of page, opposite the proper letter, and find the correction overhead given in seconds to be added to or subtracted from the time corresponding to the sine accepted. This is done in order to obtain the full value of time for the logarithm "sine of apparent time at ship." For example: Should we require the P.M. time for the log. sine of 9.70167, we would select the nearest log. to this, which is 9.70159, and find by subtraction that the difference is 8. Now the P.M. time corresponding to 9.70159 is 4 h. 01 m. 36 sec., which we note. We now apply the 8 in the foot table opposite the letter A, and find a correction of three seconds overhead, which, in this case, we add to the time selected, making the same 4 h. 01 m. 39 sec. This correction is added because in this instance the time increases as the logarithms increase, and having taken out the time for an inferior log. we must add the correction to obtain the full measure of time for the proper log.

To Convert Logarithms into Degrees. — Select from the table the degrees and minutes for the next smallest logarithm to the one given, then ascertain by subtraction the difference between them, and with this difference apply it on the same page in the proper "Dif." column, and opposite in the M. column to the left will be given the number of seconds required to complete the degrees, minutes, and seconds.

LOG-BOOK.—The log-book is a journal of all that transpires of importance on board ship. Log-books in general use may be described as follows:

Over the first column is marked the letter H., standing for the hours of the day and night, the figures below it running consecutively from midnight to noon (1 to 12) and then from noon to midnight (1 to 12), making the same divisions of the twenty-four hours as are used on shore. The log-book is kept in civil time now instead of the old method of sea time, as explained under the head of Sea Day.

Over the next column will be seen the letter K., standing for miles, or as they are nautically called, "knots."

Next will be seen the letter F., meaning furlongs, a furlong standing for one-eighth of a knot. If the ship had sailed during the watch forty miles and a half, the half knot would be entered as four furlongs. Furlongs are divided by 8 to convert them into miles.

Following along to the right we next find the word Courses, under which heading, and against the hour, will be noted the course of the ship by the steering compass. Every time the course is changed, the log must be noted, and this reading and the time recorded in the log-book under the proper headings.

Next is the column of Leeway. In this column is entered the amount of leeway for the respective courses sailed, determined by the officer of the watch.

The two following columns are for the standing of the Thermometer and Barometer.

The last column is headed Remarks, and under this head will be recorded all matters of importance occurring on board, such as carrying away sails and spars, accidents to crew, work progressing, also meeting with vessels, state of the weather, etc.

Half way between midnight and midnight (top and bottom of the page) will be seen the following headings contained in red rulings: Course, Distance, Diff. of Lat., Departure, Lat. by D. R., Lat. by Obs., Variation, Diff. of Long., Long. by D.R., Long by Obs. We will take them up in their order in dealing with them:

Course.—The bearing of the ship from her former calculated position is entered under this head. This is fully explained under the head of Dead-Reckoning.

Distance.—On the line of bearing of the ship from the former position the distance is measured in a straight line, and set down.

Diff. of Lat.—Here is entered the amount of latitude between the position last calculated and the position arrived at according to dead-reckoning.

Departure.—In this space is entered the number of departure miles (knots) the ship is either east or west of her place last calculated.

Lat. by D. R.—By applying the difference of latitude made to the latitude of the ship last determined, we obtain the latitude by dead-reckoning, the same being marked under this heading.

Lat. by Obs.—This is calculated at noon by the sextant, and the result placed in this space.

Variation.—The variations of the compass on the different courses are shown under this heading.

Diff. of Long.—The number of minutes of longitude made (estimated by using the middle-latitude as a course in Table 2, and applying the whole departure) are shown under this head.

Long. by D.R.—The longitude by dead-reckoning is found by applying the difference of longitude made to the longitude

of the ship last determined, and the same is recorded under this head.

Long. by Obs.—The longitude by observation at noon (meridian) may be calculated by equal altitudes, but, as a rule, the morning position is carried forward to noon and the afternoon position is carried back to noon, in the way explained following :

To Carry Longitude Forward.—Suppose that we should obtain a chronometer sight at 8 o'clock in the morning and determine our longitude at that time. Between the time of this sight and noon four hours elapse, and in order to find our longitude at noon all that it is necessary to do is to correct the course or courses sailed since 8 A.M.; select the departure from Table 2, turn it into minutes of longitude for the parallel of the ship, and apply this difference of longitude to the longitude of the ship found at 8 o'clock. Of course this will not be exactly the longitude by observation, but it will be so near the truth that for practical purposes it may be considered as the ship's longitude by observation at noon.

To Carry Longitude Back.—Suppose that no observation was secured during the morning, but that a sight was obtained at 4 o'clock in the afternoon. In order to carry the longitude back to noon so as to enter it in its column, we must find the difference of longitude made by the ship since noon, and apply it to the longitude of the ship found at 4 P.M.

Symbols.—Letters and numbers are sometimes employed in log-books to represent the weather, wind, and sea. The following shows the various notations :

Weather is indicated by the small italic letters : *b* (blue sky), *c* (detached clouds), *d* (drizzling rain), *f* (foggy), *g* (gloomy), *h* (hail), *l* (lightning), *m* (misty), *o* (overcast), *p* (passing showers), *q* (squally), *r* (rainy), *s* (snow), *t* (thunder), *u* (ugly, threatening),

v (visibility, clearness), *w* (wet, dew). When a bar (—) is placed under a letter it augments its signification, and when a bar and a dot ($\overline{\cdot}$) are placed under it, it signifies heavy and continuous weather of the character indicated.

Wind is denoted by the numerals, 0 (calm), 1 (light air), 2 (light breeze), 3 (gentle breeze), 4 (moderate breeze), 5 (fresh breeze), 6 (strong breeze), 7 (moderate gale), 8 (fresh gale), 9 (strong gale), 10 (whole gale), 11 (storm), 12 (hurricane).

Sea swell is indicated by the capital letters, S (smooth), M (moderate), L (long), R (rough), C (cross), H (heavy), V H (very heavy).

Remarks.—Steamship log-books are ruled slightly different from those of sailing ships, as there is no column heading for leeway; but instead there are columns for slip of wheel, etc. (See Current Sailing; Departure; Drift; Heave of the Sea; Slip of Wheel.)

Watches.—The seven watches of the log-book are named as follows:

From 8 P.M. to 12 midnight, the First Watch.
From midnight to 4 A.M., the Mid Watch.
From 4 A.M. to 8 A.M., the Morning Watch
From 8 A. M. to noon, the Forenoon Watch.
From noon to 4 P.M, the Afternoon Watch.
From 4 P.M. to 6 P.M., the First Dog Watch.
From 6 P.M. to 8 P.M., the Second Dog Watch.

The reason for the watch from 8 P.M. to midnight being called the First Watch, is because when a ship puts to sea the first watch is always set at 8 P.M. The captain always stands the first watch out, and the mate stands the first watch coming home. The captain's watch is called the starboard, and the mate's the port watch.

Note.—Never ditto figures in the log-book, but where the same course and wind are continuous, always employ ditto marks, as it will keep the log-page neater, and make it easier to read.

LOG-SLATE.—The deck slate on which the officer of the watch keeps a record of the ship's speed, course, etc., and from which the smooth log-book is made up. To enter anything on the slate is to "log" it.

LONGITUDE.—The distance of a place on the earth's surface east or west of some given prime meridian. Longitude is measured in degrees, minutes, and seconds, counting as high as 180° east and 180° west, thus completing the circumference of the globe. The meridian of 180° east and the meridian of 180° west are represented by the same line, so that a vessel may be on both at the same time. Longitude may be defined as the angle at the pole contained between two meridians, one passing through the place in question and the other through some conventional point from which longitudes are reckoned. (See Prime Meridian.) The following rules furnish the methods for finding the longitude of the ship by observations of the sun, moon, planets, and stars.

Longitude by Equal Altitudes of the Sun. — Observe an A.M. altitude (see Altitude) and at the instant of contact note the hour, minute, and second shown by chronometer. When the sun falls to the same altitude after noon, note again the chronometer. Add these two times together and divide by 2, then apply the rate correction, and the answer will show the mean time that it was at Greenwich when it was apparent noon at ship. Reduce this Greenwich mean time to apparent time by applying to it the corrected equation of time (see Equation of Time), and if

the ship is in west longitude simply turn this apparent time into degrees (Table 7), and the answer will be the longitude of the ship; but if the vessel is in east longitude, the apparent time must be subtracted from 12 hours and the remainder turned into degrees.

Remarks.—The time may also be converted into degrees by the use of the rule given under the head of Arithmetic of Navigation.

Observe the first altitude about half an hour before noon.

If, after measuring the first altitude, the ship sails toward the sun, then the original altitude must be increased one minute of arc for every mile sailed between the two sights. To make this clear, let it be supposed that the first altitude read 20° 30′ and that in the interval between the sights the ship sailed ten miles toward the sun—the instrument must be set to read 20° 40′ and the second altitude measured by that. If, on the other hand, the ship sails away from the sun after measuring the first altitude, then the reading must be decreased one minute of arc for every mile sailed in the interval, and the second altitude measured accordingly.

Longitude by One Altitude of the Sun.—Observe an altitude (see Altitude) and note the hour, minute, and second shown by chronometer at the instant of contact, and correct the latter for its rate; also correct the altitude and the sun's declination (see Rate; Corrected Altitude; Declination). Next obtain the sun's polar distance (see Polar Distance) and add to it the true central altitude and the latitude by dead-reckoning, then divide the sum of these three quantities by 2, and from the half sum so obtained subtract the true central altitude, calling the answer the remainder. Now select (Table 44) the logarithms, secant of the latitude, cosecant of the polar distance, cosine of the half sum, and sine

of the remainder—rejecting the index of each log. when it is more than 9 (see Logarithm). Add these four logs. together, divide by 2, and the answer will be the sine of the apparent time at ship when the sight was taken. With this sine, select (Table 44) the time standing against it, taking same from the A.M. column if the observation is made in the morning, but from the P.M. column if made in the afternoon. If the log. sine cannot be perfectly matched, then select the time for the nearest corresponding log. and correct the time as explained under the head of Logarithms. Apply the corrected equation of time (see Equation of Time) to the apparent time at ship according to the heading of the almanac column, so as to convert it into mean time at ship. The difference between the mean time at ship and the mean time at Greenwich will be the longitude in time, which will be turned into degrees either by the use of Table 7 or by the rule given under the head of Arithmetic of Navigation.

Remarks.—If one time is A.M., and the other time P.M., it will be necessary to add twelve hours to the P.M. time before subtracting—for instance, if the time at ship is 10 A.M. and the time at Greenwich 2 P.M., the times are four hours apart, and this is found by calling the Greenwich time fourteen hours and subtracting the ten hours from it.

The best time to take sights for longitude is when the sun is either rising or falling rapidly, so that a considerable change of altitude will only affect the time to a small extent; but do not use an altitude of less than 10°, owing to the uncertainty of the refraction.

When the sun can be observed exactly in the prime vertical (when it bears true east or west) an error of a considerable number of miles in the latitude by dead-reckoning will not produce a wrong result in the longitude. (See Prime Vertical.)

If it is desired, several altitudes may be observed in quick succession, noting the corresponding times by chronometer, and the sum of these altitudes and times divided by the whole number of altitudes taken so as to obtain the mean of the altitudes corresponding to the mean of the times. This process will eliminate any small error that might creep into a single altitude and time.

In order to understand the manner in which longitude is carried forward or back to noon from an A.M. or a P.M. sight, see explanation given under heading of Log-Book.

Longitude at Sunrise or Sunset.—Observe the sun's upper or lower limb to touch the horizon at rising or setting and note the hour, minute, and second shown by chronometer at the instant of contact, and correct the latter for its rate ; also correct the sun's declination and obtain the polar distance (see Rate ; Declination ; Polar Distance). Now add together the latitude by dead-reckoning and the polar distance and from their sum subtract 21′ if the contact of the lower limb was observed, but subtract 53′ if the contact of the upper limb was noted. Now divide the balance by 2, and to this half-sum add 21′ for a lower-limb calculation, but add 53′ for an upper-limb calculation. From this point select the various logarithms and proceed to find the longitude in precisely the same manner as directed in the preceding rule under the head of Longitude by One Altitude of the Sun.

Remarks.—The particular value of this working is in the fact that the sextant is dispensed with ; consequently, if that instrument meets with an accident and is rendered useless, the navigator is not left dependent upon his dead-reckoning for longitude.

By employing a marine glass, the contact of the sun's limb

with the horizon may be more accurately determined than by the unaided eye.

Longitude by an Altitude near Sunrise or Sunset.—At the time that the centre of the sun is in the true horizon (90° from the zenith) the lower limb has an apparent altitude of about 19′ and the upper limb about 46′.

A little time before sunrise or sunset, consult the following table and select under the figures most nearly corresponding to the height of eye, the altitude for the sun's lower or upper limb as desired, and place same on the arc of the sextant :

Sun's Semi-diameter.	Height of Eye, 13 feet.		Sun's Semi-diameter.	Height of Eye, 21 feet.	
	Altitude of Sun's Upper Limb.	Altitude of Sun's Lower Limb.		Altitude of Sun's Upper Limb.	Altitude of Sun's Lower Limb.
′ ″	′ ″	′ ″	′ ″	′ ″	′ ″
15 45	46 00	18 20	15 45	47 00	19 20
16 00	46 10	18 10	16 00	47 10	19 10
16 15	46 20	18 00	16 15	47 20	19 00

With the sextant set to the required altitude, note when the image of the sun's proper limb is in perfect contact with the horizon line, and observe the hour, minute, and second shown by chronometer at the instant of kissing. Correct the chronometer for its rate (see Rate) and add together the logarithms tangent of the ship's latitude (by dead-reckoning) and tangent of the sun's corrected declination (see Declination) ; their sum, rejecting ten from the index, will be the logarithm *sine* of an angle, which select from Table 44 and turn into time by Table 7, or by the rule under Arithmetic of Navigation. If the latitude and the sun's declination are of the same name (north or south) add the time so found to six hours at sunset, but subtract it from six hours at sunrise. If the latitude and declination are of con-

trary names, add the given time to six hours at sunrise, but subtract it from six hours at sunset. To this apparent time at ship apply the equation of time (see Equation of Time) so as to convert it into mean time at ship, after which take the difference between it and the Greenwich mean time and turn the result into degrees, which will be the longitude of the ship.

Remark.—This method should not be used beyond the parallels of 40° north and south.

Longitude by One Altitude of the Moon.—Observe an altitude (see Altitude) and note the chronometer at the instant of contact, to which time apply the rate correction, then turn this Greenwich mean time into astronomical mean time (see Astronomical Time) and next correct the moon's altitude and declination (see Corrected Altitude; Declination). Now obtain the moon's polar distance (see Polar Distance) and add to it the moon's corrected altitude and the latitude by dead-reckoning; divide the sum of these three quantities by 2 and from this half-sum subtract the moon's corrected altitude. Select (Table 44) the logarithms secant of latitude, cosecant of polar distance, cosine of the half-sum and sine of the remainder, rejecting the index of each log. when it exceeds nine. Add these four logs. together, divide by 2, and the answer will be the *sine* of a time which will be selected from the *P. M. column* (Table 44). Apply this time to the moon's corrected right ascension (see Right Ascension), subtracting it if the moon is east of the meridian, but adding it if the moon is west of the meridian—the difference or sum will be the right ascension of the meridian, from which (increased by twenty-four hours if necessary for the purposes of subtraction) subtract the sun's corrected right ascension, and the remainder will be the astronomical apparent time at ship. To this apply the corrected equation of time (see Equation of

Time) according to heading of the almanac column and the answer will be the astronomical mean time at ship; then the difference between this and the astronomical mean time at Greenwich will be the longitude in time, which turned into degrees (either by the use of Table 7 or by the rule given under the head of Arithmetic of Navigation) will be the longitude.

Remarks.—When the astronomical mean time at the ship and the astronomical mean time at Greenwich are of different dates, it will be necessary to add twenty-four hours to the time of the latest date for the purposes of subtraction between them, then the answer will be the longitude in time.

As explained for the sun, the best hour to observe a time altitude of a heavenly body is when it is the nearest to the prime vertical. (See Prime Vertical.)

If desired, several altitudes of the moon may be observed in quick succession and the corresponding times by the chronometer noted, then the mean of these altitudes and times accepted as a base from which to calculate the longitude. As explained for the sun, this will eliminate any small error as regards the altitude and noting of the time.

If the log. sine of the time cannot be matched, correct the time given in the P.M. column according to the rule given under the head of Logarithms.

Longitude by One Altitude of a Planet.—This problem is to be worked in the same way as the one described immediately preceding for the moon, simply substituting the planet's polar distance and right ascension, as may be seen by the following rule:

Add together the planet's corrected altitude, the latitude by dead-reckoning, and the planet's polar distance; divide by 2

and from the half-sum subtract the corrected altitude; select from Table 44 the logs. secant of latitude, cosecant of polar distance, cosine of half-sum, and sine of remainder; add these four logs. and divide by 2, calling the answer the sine of a time, which take out in the P.M. column, Table 44, and apply said time to the planet's corrected right ascension, subtracting it if the planet is east of the meridian, but adding it if the planet is west of the meridian—the difference, or sum, will be the right ascension of the meridian, from which (increased by twenty-four hours if necessary for the purposes of subtraction) subtract the sun's corrected right ascension and the answer will be the astronomical apparent time at the ship, to which apply the corrected equation of time, then find the difference between this astronomical mean time at ship and the astronomical mean time at Greenwich; the answer will be the longitude in time, which convert into degrees.

Longitude by One Altitude of a Star.—As explained for a planet, this problem is worked in the same manner as the moon, it simply being necessary to substitute the star's polar distance and right ascension; but it is to be explained that corrections for the declination and right ascension of stars are too small to be considered, simply accepting the same for the given year being all that is necessary. (See Fixed Stars.)

Longitude by Dead-Reckoning.—(See Dead-Reckoning.)

Longitude by the Artificial Horizon.—(See Artificial Horizon.)

LONGITUDE IN ARC.—The position or distance of a vessel east or west of a given prime meridian, expressed in degrees, minutes, and seconds of angular measure.

LONGITUDE IN TIME.—The position or distance of a

vessel east or west of a given prime meridian, expressed in hours, minutes, and seconds of time measure.

LOST DAY.—(See Circumnavigator's Day.)

LOWER LIMB.—(See Upper Limb.)

LOWER TRANSIT.—The passage of a heavenly body over the meridian 180° distant from the meridian of the upper transit. In high northern and southern latitudes at certain times of the year the sun and moon do not set during the twenty-four hours, but circle around the heavens, at all times in view of the observer; consequently they are then seen at the period of their lower as well as upper transit. The Nautical Almanac gives the astronomical times of the upper transit of heavenly bodies, which takes place when the bodies are moving (apparently) from east to west. (See Upper Transit; Midnight Sun.)

LOW LATITUDES.—Parallels in the vicinity of the equator. (See High Latitudes.)

L'S OF NAVIGATION.—Lead, Lights, Lookout, Latitude, Longitude.

LUBBER'S POINT.—The vertical black line painted on the inside surface of the compass bowl, and which represents the ship's head and the line of the keel.

LUNAR.—Relating to the moon.

LUNAR DAY.—The interval of time between two successive transits of the moon over the same meridian.

LUNAR DISTANCE.—The angular measurement of the moon from another heavenly body.

LUNAR INEQUALITY.—A variation in the moon's motion which depends upon its distance from the sun.

MAGNET.—An ore that attracts iron. The properties of a magnet are that, with the exception of the oxides, it attracts iron in all of its various states. If a bar of steel is charged with magnetism, either by a magnet or by a dynamo, then suspended, horizontally balanced by a slender thread, the bar will indicate the magnetic meridian. What is known as an artificial magnet is a bar or mass of iron or steel into which the magnetic property has been introduced by the presence of, or contact with, a body possessing the same.

MAGNETIC.—Having power to attract iron.

MAGNETIC AMPLITUDE.—The bearing by compass of a heavenly body at rising and setting, or an arc of the horizon intercepted between the body in its rising and setting and the east and west compass points.

MAGNETIC AZIMUTH.—The arc of the horizon intercepted between the vertical circle and the magnetic meridian, or the bearing by compass of a heavenly body, calculated from the north point in north latitudes and the south point in the southern hemisphere.

MAGNETIC BEARING.— A bearing according to the compass, or the direction pointed out by the magnetic needle.

MAGNETIC DIP.—A property belonging to the magnetic needle, whereby one of its poles (ends) inclines toward the earth, while the other pole is repelled or elevated.

MAGNETIC EQUATOR.—A line passing through those points on the surface of the earth where the dipping needle rests in a horizontal position. (See Compass.)

MAGNETIC INDUCTION.—Communication of magnetism from a magnet to a body of iron in its vicinity, although per-

haps not touching it. The communication of magnetism from the earth (which is a huge magnet in itself) to the hulls of iron and steel vessels is known as the earth's induction.

MAGNETIC MERIDIAN.—A vertical circle in the heavens which intersects the horizon in the magnetic poles; or it may be defined as the natural direction pointed out by the compass needle when allowed to turn freely and removed from the effects of deviation and local attraction.

MAGNETIC NEEDLE.—The slender piece of magnetized steel to which the compass card is fastened.

MAGNETIC POLES.—Two places on the earth's surface where the dipping needle assumes a position perpendicular to the horizon and shows a dip of 90°. The north magnetic pole is situated on the parallel of 70° north and on the meridian of 97° west; the south magnetic pole on the parallel of 73° south and on the meridian of 146° east.

MAGNITUDE.—According to their brilliancy the stars are classed as of the first, second, third, fourth, fifth, sixth, and seventh magnitudes. Stars beyond the seventh magnitude cannot be seen with the unaided eye, and are known as telescopic stars.

MAKING THE LAND.—A landfall; to obtain the first view of land.

MAST-HEAD ANGLES.—To measure the distance between the observer's ship and another vessel, it is only necessary to know the height of her mast or smoke-stack, and the vertical angle of the same measured to the surface of the water—to her water-line. If the image of the truck, or the rim of the smoke funnel is thrown to the water-line by the sextant, and this angle

referred to the danger-angle tables in the back of this book, the distance of the vessel will at once be obtained by simple inspection.

To tell, when in a race, if the distance between two vessels is increasing or decreasing, note several mast-head angles. If the angles increase it proves that the two vessels are drawing nearer, but if the angles decrease the vessels are separating more and more. (See Danger-Angle Tables.)

MAST-HEAD COMPASS.—A compass hung at the lower-mast-head so as to remove it out of the influence of the magnetism in the ship's iron. (See Elevator Compass.)

MEAN NOON.—The time that the mean sun is supposed to cross the observer's meridian.

MEAN SOLAR TIME.—Time calculated by the motion of the mean sun. All watches and clocks represent mean solar time.

MEAN SUN.—An imaginary sun which is supposed to move uniformly and to cross the same meridian the same time every day, thus giving a value of exactly twenty-four hours to the day. This mean or fictitious sun sometimes crosses the observer's meridian a little in advance of the true sun, and at other times a little after it, and this difference or interval between the real and imaginary suns is known as the equation of time.

By referring to the almanac it will be seen that four times in each year the real and imaginary suns pass the same meridian at the same time; namely, about April 14th, June 13th, August 31st, and December 23d; consequently on these days the equation of time may be considered as zero. The maximum equation of time is about 16 m. 20 sec.

MEAN TIME.—Same as mean solar time.

MERCATOR'S CHART.—(See Chart.)

MERCATOR'S SAILING.—A method of finding (indepen dent of the parallel rules and dividers) the true course and distance between two places by employing meridional parts instead of the middle latitude.

Rule.—Find the difference of latitude and the difference of longitude between the two places. If the two latitudes have the same name (both north or both south) subtract one from the other, but if they have different names add them together. Now multiply the degrees of the answer by 60 to convert them into miles and add in the minutes as they represent miles ; the answer will be the difference of latitude. Proceed to find the difference of longitude in the same way—add the longitudes together if of different names, but subtract between them if of the same name.

Turn to Table 3 and select the meridional parts for the degrees and minutes of each latitude, and if the latitudes are of different names, add the meridional parts, but if the latitudes are of the same name, subtract one of the meridional parts from the other. In other words, if the latitudes were added the meridional parts must be added, and if the latitudes were subtracted the meridional parts must be subtracted.

With the meridional difference of latitude and the difference of longitude turn to Table 2 and make them compare by seeking in the latitude column for the meridional difference of latitude and in the departure column opposite for the difference of longitude. On the page of their comparison the true or geographical course between the two places will be read in degrees from the top of the page if the meridional difference of latitude is greater

than the difference of longitude, but it will be read from the bottom of the page if the difference of longitude exceeds the meridional difference of latitude.

On the same page apply the proper difference of latitude in the latitude column from that part of the page (top or bottom) where the course was read, and opposite to the left in the distance column will be found the distance in nautical miles for the course found, which, in other words, will be the number of miles required to be sailed on a direct line between the ship's place and the point sought.

The variation (also the deviation, if any exists) of the compass must be applied to the true course in order to convert the same into a magnetic course, or the course necessary to be steered by the ship's compass in order to make the true track.

To Apply Variation.—Suppose the true course found is southeast, and the chart informs us that in the ship's locality there is one point of westerly variation. The effect of this is that the southeast point of the compass is swung so that it really points southeast-by-east, and in order to make a true southeast course the ship must be steered southeast-by-south according to the compass.

Rule.—A simple rule to remember for converting a true course into a magnetic course is to allow westerly variation away from the true course in the direction that the hands of a watch revolve, and easterly variation contrary, or against the hands of a watch.

To Apply Deviation.—If deviation exists for the magnetic course found, the latter must have the deviation applied to it on exactly the same principle as explained for variation. For example, we will say that the magnetic course found is southeast-by-south, and that there is one point of westerly deviation to be

allowed for when the ship's head is on that course. The compass course to be steered in this case is south-southeast, in order to make a correct magnetic course of southeast-by-south.

Remarks. — The variation must always be applied before applying the deviation.

It is to be remembered that the compass course must be reshaped as often as the variation changes. For example, we will say that the true course from Sandy Hook to Bermuda Island is S. 42° E., and that in the vicinity of Sandy Hook the variation of the compass is 8° westerly. The magnetic course in this case is S. 34° E., which equals southeast-by-south. To this course we apply the deviation correction (if any exists) given by our deviation card or found by observation, and then we hold the indicated compass course until we reach a latitude and longitude where the variation of the compass is shown to change, when it becomes necessary for us to apply the new variation given by the chart and change the course accordingly.

When, by reason of opposing winds or other causes, the vessel does not keep on the direct course for the port bound to, then the whole process of laying out the course must be gone through with again. This may happen many times before the port is reached.

Mercator's Sailing is to be preferred to Middle Latitude Sailing, unless the course is nearly east or west.

MERCURIAL BAROMETER. — An instrument which shows the pressure of the air or weight of the atmosphere. It is a tube thirty-four inches long, closed at the top and exhausted of air. The lower end of this tube is immersed in a cup or cistern of mercury, and the pressure of the atmosphere causes the fluid to ascend in the slender, hollow column. The variation in height of the mercury is dependent upon the weight or

pressure of the atmosphere. These variations are measured by aid of a scale graduated in inches and parts and fixed against the tube. When the mercury in the cistern is pressed down by the air the mercury rises in the exhausted tube, but when the mercury in the cistern rises on account of diminished pressure of air the mercury in the tube falls. (See Barometer.)

MERIDIAN.—The highest point of the great arc described by a heavenly body from its rising to its setting. When the sun crosses the observer's meridian it is 12 o'clock, apparent noon, at his place. A meridian is an imaginary great circle of the sphere extending from pole to pole. (See Circumnavigator's Day; Prime Meridian; Secondary Meridians; Tertiary Meridians.)

MERIDIAN ALTITUDE.—The angular height of a heavenly body from the horizon line at the time the body is crossing the meridian. (See Altitude; Latitude.)

MERIDIAN PASSAGE.—The crossing of a heavenly body over the meridian of the observer. (See Lower Transit; Upper Transit.)

MERIDIAN SAILING.—Sailing on a meridian; sailing true north or south. (See Parallel Sailing.)

MERIDIONAL DIFFERENCE.—The quantity given in Table 3, which bears the same proportion to the difference of latitude that the difference of longitude bears to the departure.

MERIDIONAL PARTS.—Degrees of latitude increased from their natural lengths more and more as the equator is receded from, and the lengths of the small portions of the meridian thus increased, expressed in minutes of the equator, are called meridional parts. (Table 3.)

METEOROLOGY.—The science of the atmosphere and its phenomena. (See Log-Book ; Weather.)

MIDDLE LATITUDE.—Half of the sum of two latitudes of the same name, but half of the figures left after subtracting between two latitudes of different names. The middle latitude between 20° north and 30° north is 25° north. The middle latitude between 20° north and 30° south is 5° south.

MIDDLE-LATITUDE SAILING.—The method of finding (independent of the parallel rules and dividers) the true course and the distance between two places by employing the middle parallel between them.

Rule.—Find the difference of latitude and the difference of longitude between the two places. If the two latitudes have the same name (both north or both south) subtract one from the other ; but if they have different names add them together. Now multiply the degrees of the answer by 60 to convert them into miles, and add in the minutes as they represent miles ; the answer will be the difference of latitude. Proceed to find the difference of longitude in the same way : add the longitudes together if of different names, but subtract between them if of the same name.

Next, to find the middle latitude : if the two latitudes are of the same name add them together and divide by 2 ; but if they are of different names subtract one from the other and divide by 2. The answer will be the parallel equidistant between the place of the ship and the port sought.

With this middle latitude turn to Table 2, and on the page marked with the degrees of the middle latitude apply the difference of longitude in the distance column, and opposite to the right in the latitude column (reading from the top of the page if

the degrees were found there, but from the bottom of the page if the degrees were found there) will stand the departure, or the number of nautical miles in an east and west line between the ship and the sought-for port.

Now, with the difference of latitude and the departure make them compare in Table 2 in their respective columns opposite one another, and in the distance column to the left will be seen the direct distance to be sailed in nautical miles, and the true or geographical course between the two places will be read in degrees from the top of the same page if the difference of latitude is greater than the departure, but the course will be read from the bottom of the same page if the departure exceeds the difference of latitude.

The variation (also the deviation, if any exists) of the compass must be applied to the true course in order to convert the same into a magnetic course, or the course necessary to be steered by the ship's compass, in order to make the true track.

To Apply Variation.—Suppose the true course found is south and the chart informs us that in the ship's locality there is one point of easterly variation. The effect of this is that the compass south point is swung so that it really points south-by west, and in order to make a true south course we must steer south-by-east by the compass.

Rule.—A simple rule to remember for converting a true course into a magnetic course is to allow the amount of westerly variation away from the true course in the direction that the hands of a watch revolve, and easterly variation contrary or against the hands of a watch.

To Apply Deviation.—If deviation exists for the magnetic course found, the latter must have the deviation applied to it on exactly the same principle as explained for variation. For ex-

ample, we will say that the magnetic course found is northeast, and that there is half a point of westerly deviation to be allowed for when the ship's head is on that course. The compass course to be steered in this case is northeast-half-east, in order to make a correct magnetic course of northeast.

Remarks.—The variation must always be applied before applying the deviation.

It must be borne in mind that the compass course is to be reshaped as often as the variation changes. For example, we will say that the true course found is N. 45° E., and that in the locality of the ship the variation of the compass is 6° easterly. The magnetic course in this case is N. 39° E., which equals northeast half-north. To this course we apply the deviation correction (if any exists) given by our deviation card or found by observation, and then we hold the indicated compass course until we reach a latitude and longitude where the variation of the compass is shown to change, when it becomes necessary to apply the new variation given by the chart, and change the course accordingly.

When by reason of head winds or other causes the vessel does not keep on the direct course for the port to which she is bound, then the whole process of laying out the course must be gone through with again. This may occur many times before the port is reached.

Middle-Latitude Sailing is to be preferred to Mercator's Sailing when the course is nearly east or west.

MIDDLE POINT.—(See Drift.)

MIDNIGHT SUN.—As explained under the head of Lower Transit, in high latitudes during the summer season there are times when the sun does not set for the observer during the

twenty-four hours, and on account of crossing at 12 o'clock at night the meridian 180° distant from the meridian which it crossed when it made its upper transit, it derives its name of the midnight sun.

MILE.—A statute mile is 5,280 feet; a nautical or geographical mile 6,082.66 feet; the latter is also called a knot.

MINUTE.—A mile of latitude and a minute of latitude are of equal value—6,082.66 feet. A minute of longitude varies in value according to the distance from the equator. At the equator a minute of longitude is equal to a minute of latitude. On the parallel of 60° north or south a minute of longitude is equal to only half a minute of latitude. Longitude value decreases in proceeding from the equator toward the poles, where it is lost, all the meridians converging to a point; consequently neither the north nor south poles possess longitude.

MINUTE OF ARC.—A minute of angular measure; a minute measured on the sextant.

MIRROR.—(See Sextant.)

MIXED TRACK.—(See Great-Circle Sailing.)

MOON.—An opaque celestial body receiving its light from the sun; mean distance from the earth 238,800 miles; diameter 2,160 miles; mean apparent diameter 32′.

MOON CULMINATING STAR.—A star that crosses the meridian at the same time that the moon makes its transit.

MORNING STAR.—When a planet rises before the sun it is called the morning star, and when it appears in the western sky shortly after sunset it is called the evening star.

NADIR.—The point of the heavens vertically under the observer's feet. The nadir is diametrically opposite to the zenith.

NATIONAL OBSERVATORY.—An astronomical establishment situated in the capital city of a nation. The meridian which passes through the observatory is accepted as the first or prime meridian of that country. (See Prime Meridian.)

NAUTICAL ALMANAC.—(See Almanac.)

NAUTICAL ASTRONOMY.—That part of astronomy which is used for determining the latitude and longitude of the ship by calculations of the sun, moon, and stars. Amplitudes and azimuths also belong to nautical astronomy.

NAUTICAL DAY.—Same as sea day.

NAUTICAL MILE.—(See Mile.)

NAUTICAL STARS.—Certain bright stars tabulated in the Nautical Almanac, used by navigators for determining the vessel's position. The principal ones are given in the star tables in the back of this volume, and under the head of Fixed Stars. (See Latitude.)

NAUTICAL TABLES.—Specially computed tables for the solution of navigation problems. Bowditch's tables, published by the United States Government, are accepted by the naval authorities of all nations as standard, although England, France, and other countries have their own tables. Bowditch's tables are the ones referred to throughout the text of this work.

NAVIGATING COMPASS.—The standard compass.

NAVIGATION.—The science of locating the position of a ship at sea, and conducting a vessel from one port to another.

NEUTRAL POINT.—A magnet in the shape of a steel bar has a north polarity at one end and a south polarity at the other. The middle of the bar is fairly devoid of magnetism, and this space is called the neutral point.

NOCTURNAL.—Relating to the night.

NOCTURNAL ARC.—The arc described by a heavenly body from its setting to its rising.

NODE.—When a planet crosses from north to south it is in the descending node, and when it crosses from south to north it is in the ascending node.

NOON.—When the centre of the real sun is on the observer's meridian it is apparent noon not only with him but at all places on his meridian from pole to pole. (See Mean Sun; Siderial Noon.)

OBJECT-GLASS.—The lens situated in the large end of a telescope, the same being the first to receive the image or rays of light.

OBSERVATION.—To determine the angular height of a heavenly body above the horizon for the purpose of calculating the ship's position.

OCCULTATION.—The eclipse of one heavenly body by another.

OCTANT.—A nautical instrument of reflection for measuring altitudes of heavenly bodies. It is constructed on the same principles as the sextant, but of more limited arc and graduated to only 15″ instead of 10″. The metal-frame and silver-arc octant with an arc reading to about 120° is a much superior instrument in every way to the quadrant. The manner of adjusting and using the octant is identical with that of the sextant, consequently it would be repetition to treat the subject under this head, and the reader is referred to the rules given under the head of Sextant. Some old-fashioned octants are cut to 20″ of arc and others even to 30″. (See Quadrant; Sextant.)

OFF THE ARC.—(See Sextant.)

OIL COMPASS.—A liquid compass; a compass in which the card floats about in oil instead of a mixture of alcohol and water. (See Liquid Compass.)

ON THE ARC.—(See Sextant.)

OPPOSITION.—When a heavenly body is 180° of longitude distant from the sun it is said to be in opposition.

ORBIT.—The imaginary path described by a heavenly body in its revolution; the track of a planet round the sun.

P.M.—Post Meridiem; after meridian; embraces the twelve hours from noon to midnight.

PARALLAX.—The apparent displacement of a heavenly body as seen from two different stations. The sun's parallax is shown in Table 16; the moon's parallax (less refraction) in Table 23, and the parallax of the planets in Table 17. (See Corrected Altitude; Horizontal Parallax.)

PARALLEL RULES.—Two flat rules connected with pivoted cross-hinges so that the rules may remain parallel when spread out. They are used for shaping courses and determining bearings on the chart.

PARALLELS.—Circles of latitude parallel to the equator.

PARALLEL SAILING.—Sailing on a parallel; sailing true east and west. (See Meridian Sailing.)

PARHELION.—A mock sun; an image of the sun which is occasionally seen close to and at the same height above the horizon as the true sun.

PASSAGE.—(See Meridian Passage.)

PATENT LOG.—An instrument for measuring the distance

(in nautical miles) run by a vessel. It consists of a register, rotator, and line, the latter connecting the two metal parts. The rotator is towed astern, and by its revolutions turns the line communicating with the register and turns the dial hands within.

To Rig the Log.—Pass the log-line through the long fore-and-aft hole in the rotator and make a small Flemish eye in the end of the line; then sew a piece of leather for chafing gear around that part of the line which rubs against the small or forward end of the rotator. Next secure the Flemish eye to the after-part of the rotator by the wooden or metal peg furnished, and fasten the hook to the other end of the line by a couple of half-hitches. Secure the indicator so that it will ride freely on the taffrail, permitting the angle of the indicator bar to correspond with the angle of the line, thus preventing undue friction upon the shaft-bearing when the log is being towed. Give line to the rotator according to the freeboard and speed of the vessel. A very high freeboard, or a steamer making more than ten knots, will require all the line furnished to prevent the rotator from skipping, whereas a low freeboard or a vessel making anywhere from five to ten knots will require about two-thirds of the line.

To Read the Dial.—Some registers have two and some three dials. In the latter case the first one is marked in quarters, each division representing one-quarter of a mile; the second in even miles, recording as high as ten; the third in ten-mile divisions, recording as high as one hundred. When the ship has sailed one hundred miles, the three hands all point at zero, and at such time a suitable memorandum is made in the log-book, so that the record may be faithfully preserved. Where the register has only two dials, one of them represents quarter miles and the other single-mile divisions extending to one hundred.

Remarks.—When a vessel's speed exceeds eighteen miles an

hour, the majority of patent logs are of little value, as they will not record correctly the distance run by the vessel on account of skipping. If sufficient line is given them to overcome this skipping and attendant loss, they will be too sluggish to render an honest return. In such cases recourse is had to the chip log, and the rough distance run is also calculated by dividing the number of revolutions made by the propeller by the number allowed for one mile.

To Allow for Current.—When a ship is sailing with or against a current, the velocity of same must be taken into account and applied either as a plus or minus quantity to the reading of the dial.

Examples.—According to the register, the vessel heading west has made ten miles in the past hour, but it is known that during that time the ship has been in a current flowing west at the rate of two miles an hour ; consequently this two miles must be added to the reading of the register, making the corrected distance run twelve miles.

The register shows that during the past hour the vessel heading south has made ten miles, but it is known that during that time the ship has been in a current setting north at the rate of two miles an hour ; consequently this two miles must be subtracted from the reading of the register, making the corrected distance run only eight miles.

Explanation.—When a vessel is going neither directly with or against a current, but sailing a course that makes an angle with it, then it becomes a calculation of current sailing, and must be considered in the manner explained under that head.

PATTERSON'S METHOD.—(See Chart Sailing.)

PELORUS.—An instrument much used for observing bear-

ings and for finding the deviation of the compass, taking the place of the azimuth attachment, shadow-pin, etc. It consists of a circular dial of brass graduated with the points and degrees of the compass, and two upright arms which revolve around the circle. This plate is hung in gimbals so that it will preserve a horizontal position when the vessel pitches and rolls. One of the uprights is fitted with a perpendicular thread running its length, also a small hinged mirror at its base, and the other upright is provided with a colored eye-screen which is made to slide up and down the length of the arm, and is for the purpose of protecting the eye from the glare of the sun when taking a bearing of that body. A mark on the inner gimbal ring indicates the line of the keel or the ship's head, and a clamp screw admits of the dial being secured against turning after it has been set.

Pelorus Stands.—Suitable stands for the pelorus should be provided on different parts of the deck, in order that bearings may be taken at any station by simply carrying the pelorus to it and setting it on its stand. The idea of this is that if the view is obstructed (by a mast, funnel, sail, or deck-house) from one point, another may be selected which will give a clear field. It is recommended that steamships have stands built on each end of the bridge and on each quarter. These stands require to be but simple shelves hinged to the rail and provided with raised strips or coamings of wood running round them for the pelorus box to snugly set into and to protect the same from rolling off. The stands must have their fore-and-aft coamings parallel to the ship's keel, so that when the pelorus box is placed, the zero line of the card will coincide with the line of the keel. The manner of effecting this is explained in the following:

The ship being on an even keel while in dock or at anchor in the stream, set the pelorus square on one of the shelves, with the

lubber's mark forward, and measure carefully the distance from the centre of the instrument to the midship seam of the deck, then lay off toward the bulwarks from this seam a conspicuous mark on the forward deck (on the side that the instrument is on) the same distance as exists between the pelorus and the seam. Next set the zero point of the pelorus dial to the lubber's mark on the gimbal ring, and observe that the sight-vanes are placed at zero. Look forward through the sight-vanes at the mark erected, and move the box one way or the other until the mark is seen to be cut by the thread. Now secure the coamings on the lines indicated by the box, and proceed in a like manner for each one of the shelves.

To Take a Bearing.—Set the pelorus to the course of the ship according to the standard or navigating compass, then so long as the ship is held steady on said course, any bearings taken by the pelorus will represent the magnetic bearing of the object exactly the same as though it had been observed directly from the standard compass itself.

In order to find the deviation of any particular compass, simply set the pelorus to the course of the ship as shown by that compass, and proceed to take the sun's bearing and work out the amplitude or azimuth. (See Amplitude ; Azimuth.)

PERMANENT MAGNETISM.—An artificial steel magnet will part with a little of its original strength after being charged, the balance constituting what is known as its saturation point, which it will retain for many years without appreciable loss, and is known as permanent magnetism.

PERPENDICULAR.—A line at right angles to the plane of the horizon ; a plumb-line ; a line at a right angle to the base.

PERSONAL EQUATION.—The difference in judgment

shown between two observers in measuring an altitude of the same object, etc.

PLANE.—A level surface. In astronomy planes are ideal and pass through certain points of the heavens—planes of the horizon, equator, etc.

PLANE CHART.—A chart representing the earth's surface as a plane.

PLANE SAILING.—Calculating courses, etc., on the supposition that the surface of the earth is a plane.

PLANET.—An opaque celestial body, which, like the moon, receives its light from the sun. The nine principal planets are Mercury, Venus, Earth, Moon, Mars, Jupiter, Saturn, Uranus, Neptune. (See Fixed Stars.)

PLANISPHERE.—A chart of the heavens.

PLOTTING.—To plot the latitude and longitude of a vessel is to trace on a chart the courses and distances made. Where the last line ends will be the ship's place. It is a modification of dead-reckoning.

POINT.—One of the thirty-two divisions of the compass card ; exact place ; station.

POINTERS.—The two stars in the ladle of the Dipper that point out the North Star. (See Dipper.)

POLAR CIRCLES.—The two parallels situated 23° 28′ from the poles of the earth. (See Antarctic Circle ; Arctic Circle.)

POLAR DISTANCE.—The angular distance of a heavenly body from the elevated pole, the same being found by either adding its declination to or subtracting it from 90°. Polar distance is reckoned from the pole that is in the hemisphere of the observer. For example, if the observer is in north latitudes, the

angular distance of the body would be figured from the elevated north pole, and if the observer was in the southern hemisphere, it would be measured from the south pole.

Examples.—An observer situated north of the equator wishes to know the sun's polar distance. The declination of the body is 10° north ; consequently the sun's north polar distance is 80°.

An observer situated south of the equator requires the moon's polar distance. The declination of the body is 20° north ; consequently the moon's south polar distance is 110°.

POLARIS.—The Pole or North Star. It is a star of the second magnitude in the tail of the Little Bear. Polaris is only about $1\frac{1}{6}°$ from the pole, and its altitude is always the approximate latitude of the observer. When Polaris is at its greatest distance from the meridian its altitude is practically the same as the elevation of the pole, which is equal to the latitude of the observer. Polaris is calculated to be many, many hundreds of millions of miles from the earth. Polaris is approaching the pole, and in a hundred and twenty years from now it will be about 30′ from it, after which it will commence to recede. These changes arise from the precession of the equinoxes. The annual variation of the declination of Polaris is 19″ ; in other words, it is approaching the pole at the rate of 19″ yearly.

POLE COMPASS.—A compass that is elevated above the deck by means of a long, stout pole. Access is had to the instrument by a ladder fixed permanently between the deck and the top of the pole. The compass is so situated to remove it beyond the disturbing influences of the ship's iron.

POLES.—The extremities of the earth's axis ; the two points on the earth's surface 90° distant from the equator. (See Magnetic Poles.)

POSITION.—Relating to the place of the ship.

PRECESSION OF THE EQUINOXES.—The equinoctial points do not preserve a constant place among the stars, but move backward, or toward the west, along the ecliptic at the annual rate of 50″; consequently a complete revolution occupies 25,868 years. The precession is caused by the unequal attraction of the sun and moon on the equator, combined with the earth's rotation on its axis.

PRICKING POSITION.—With the dividers take from the graduated meridian on the side of the chart the given latitude and mark this on the meridian the nearest to the given longitude; then lay the bevelled edge of the parallel rules on a near parallel and slide them along to the point marked on the meridian. Now with the dividers take the given longitude from the graduated parallel and lay this down along the edge of the parallel rules, and this will define the ship's latitude and longitude.

PRIMARY MERIDIAN.—Same as Prime Meridian.

PRIME MERIDIAN.—The starting-point of longitude. The first meridian of a country established by the situation of its national observatory. Longitude is counted east and west from the first meridian up to 180°. The French use the meridian of Paris as a first meridian; the English that of Greenwich; the Russians that of St. Petersburg; the Americans that of Washington, etc. For convenience, American navigators (and others) also use the meridian of Greenwich, as it permits them to navigate by English charts, many of the same representing parts of the world of which we have no survey of our own. For purposes of navigation, a chronometer must be regulated to the prime meridian of the country whose chart is used—if a French chart is employed, the chronometer must be set to Paris time;

if an English chart is used, the chronometer must represent Greenwich time, etc. (See Circumnavigator's Day; Secondary Meridians.)

PRIME VERTICAL.—The vertical circle passing through the east and west points of the horizon. A heavenly body is in or on the prime vertical when it bears true east or true west—when it is at right angles to the meridian. When a body is observed on the prime vertical for the purpose of calculating the longitude, a considerable error in the latitude by dead-reckoning (used in the computation) will not appreciably affect the result. By this it will be understood that the best time to observe a longitude sight (be it sun, moon, planet, or star) is when the body is on the prime vertical; but it is to be explained that it is not always possible to obtain such an observation, for a heavenly body can only bear true east or true west when its declination is of the same name as the ship's latitude and less than the latter. When the declination of the body is of the same name but greater than the ship's latitude, the body's nearest approach to the prime vertical will be some time after it has risen; but when the declination is of a contrary name to the latitude, the body will be the nearest to the prime vertical at its rising and setting. By referring to a set of azimuth tables the navigator will be able by mere inspection to determine the hour and minute that the body will be on or will approach the nearest to the prime vertical. All that is necessary is to refer to the page showing the ship's latitude and the declination, then run down the latter column until the closest figures to 90° are obtained, and look opposite in the side column for the time. When the declination and the latitude are nearly the same, the sun will be nearest the prime vertical a short time before and after its merid-

ian passage, consequently at such times a very high altitude may be employed for finding the longitude of the ship.

PRISMATIC ATTACHMENT.—A small portable instrument fitted with a prism-glass, so adjusted on top of the compass glass that the bearing of an object may be read from the compass card by reflection.

PROJECTIONS.—Charts ; maps ; delineations.

PROTRACTOR. — An instrument for measuring angles. (See Course Protractor.)

QUADRANT.—A navigating instrument of reflection used for measuring angles. It is on the same principle as the octant and sextant, but inferior in construction and graduated only to 1′ of arc.

Description of the Quadrant.—The quadrant contains an arc of 45°, but owing to its double reflection it measures 90°, reading from right to left. The arc is divided into degrees, and these are subdivided into three parts of twenty minutes each, and the vernier on the sliding limb is divided into single minutes. The sliding or index limb is moved from right to left in measuring altitudes, and the screw on the back is used for clamping it against the arc after the altitude has been roughly measured. The screw on the forward part of the limb is called the tangent screw (set tangent to the arc) and is used for gently moving the sliding limb when it is clamped so as to make a perfect contact of the body with the horizon. The colored glasses are for shading the eye when obtaining an altitude of the sun.

To Read the Altitude.—Ascertain the number of degrees and thirds of a degree that the zero on the vernier has passed on the arc, then look along the vernier until one of its lines cuts ex-

actly with one of the lines on the arc, and the number of minutes given on the vernier will be added to the reading originally obtained on the arc—the whole answer being the required altitude.

Remarks.—The quadrant is a crude instrument, and is not used by good navigators. The metal-frame octant and the sextant are standard instruments, but on account of the sextant affording means of measuring greater angles than the former, it is to be preferred to the octant.

The quadrant is adjusted in the same manner as explained for the sextant. (See Octant; Sextant.)

QUADRANTAL DEVIATION.—The deviation of the compass arising from the effects of the induced magnetism in thwartships and fore-and-aft iron in the ship, and which is corrected by two iron spheres attached to the port and starboard sides of the binnacle. These spheres are known as quadrantal correctors.

QUADRATURE.—When the moon is 90° from the sun—at one of the two points in her orbit equally distant from the conjunction and opposition—she is said to be in quadrature.

RADIUS.—The distance from the centre of a circle to its circumference.

RATE.—The daily variation of a chronometer from the time of the meridian to which it is set. The aggregate of the gain or loss is respectively subtracted from or added to the face of the chronometer in order to obtain the correct Greenwich mean time at the instant of observation.

Sea Rate.—Sometimes the chronometer does not maintain when at sea the rate furnished for it by the makers or dealers, and which is known as the instrument's shore rate. To as-

certain the sea rate, take the difference between the chronometer's error on the day of sailing and the gross error determined when the vessel makes port, and the result divided by the number of days at sea will be the sea rate. (See Chronometer.)

RATIONAL HORIZON.—A plane passing through the centre of the earth and parallel to the sensible horizon at the observer's station. (See Sensible Horizon.)

READING.—To read an altitude is to observe the height of an object recorded on the arc of a sextant, octant, etc.

RECIPROCAL BEARINGS.—Mutual bearings of the same object by two compasses placed in line, one on board and the other on shore where it is free from magnetic disturbances in the way of local attraction.

REDUCTION.—To change hours, minutes, and seconds into arc, or to change degrees into time. To apply a certain quantity of arc to an ex-meridian altitude is called reduction to the meridian.

REFRACTION.—The change of direction of a ray of light in passing through atmospheric mediums of varying density. Refraction is ever a minus correction, and is tabulated in Table 20 for all heavenly bodies. It is to be explained, however, that Table 23 gives the parallax of the moon, less the refraction. (See Corrected Altitude.)

REGULATING.—What is known as regulating a watch or clock at sea is simply to correct it so that it will show the local apparent time at ship. It is done as follows: Observe an altitude of the sun as for a regular chronometer sight for finding longitude, and also note the time shown by the ship's clock at

the instant; then proceed to work up the sight by the regular rule (see Longitude), and compare the apparent time at ship given for the sine of the logarithms with the time shown by the clock when the sight was taken ; the difference will be the error of the clock, the hands of which will be set back or advanced as required. This method is also known as finding the time.

RESIDUAL ERRORS.—Deviation remaining after the compass has been adjusted as closely as possible. (See Compass.)

RETENTIVE MAGNETISM.—When a ship's head has been in one direction for a long time either at a dock or on a long course at sea, the hull becomes temporarily magnetized in a direction parallel to the magnetic meridian, owing to the earth's inductive force. Sometimes this magnetism remains for several hours after the direction of the ship's head has been changed, hence its name "retentive." It then gives way to magnetism induced in a new direction according to the change of course. It is because of this retentive magnetism that the deviation card should be continually checked at sea, especially upon changing the course. The temporary effect of retentive magnetism upon the compass is to cause it to deviate invariably in the direction of the last course, hence if a vessel has been heading south for several days, and her course is changed to west, it will be found that the natural deviation for that point has been increased if the deviation has been westerly, and diminished if it has been easterly.

REVOLVING STORM.—(See Law of Storms.)

RHUMB LINE.—The track of a ship sailing constantly toward the same point of the compass; a line prolonged on a nautical chart from any point of the diagram compass.

RIGHT ASCENSION.—The distance considered in time of

a heavenly body reckoned eastward on the equinoctial from the First Point of Aries—counted from 0 h. to 24 h. (0° to 360°). The First Point of Aries is that point in the heavens which the sun's centre occupies at the time of the vernal equinox, when the body changes from south to north declinations. Right ascension may be expressed as the celestial longitude of a heavenly body. The correction for the hourly or minute difference of right ascension is found and applied in the same way as explained for the difference of declination. In other words, the right ascension is reduced to the Greenwich time of observation as shown by the chronometer, by multiplying the hourly difference in the case of the sun and planets, but the minute difference in the case of the moon, and then adding this correction to or subtracting it from the right ascension proper according as the latter is increasing or decreasing.

RIGHT ASCENSION OF THE MERIDIAN.—The angle at the pole included between the meridian of the observer and the meridian passing through the First Point of Aries. It is reckoned eastward in the order of the signs. Sidereal time and right ascension of the meridian are one and the same thing. In other words, the hour angle of the First Point of Aries is equal to the right ascension of the meridian of an observer, which is precisely the same thing as sidereal time.

RIGOROUS METHOD.—Navigation problems calculated according to exact principle ; allowing of no abatement ; accurate in the smallest detail.

RISING.—The appearance of a heavenly body mounting above the horizon. Celestial bodies continue to rise from the eastern horizon line until they cross the meridian of the observer, when they begin to fall.

ROUGH LOG.—Same as log slate.

SAILINGS.—(See Great-Circle, Mercator's, Meridian, Middle-Latitude, Parallel, Plane, and Spherical Sailings.)

SATURATION POINT.—(See Permanent Magnetism.)

SEA DAY.—The old fashioned way of keeping the date at sea was to consider the day and date to commence at noon and to end and begin again the following noon, so that the sea day and date began twelve hours before the civil date and twenty-four hours before the astronomical date. This ridiculous practice belongs entirely to the past.

SEA RATE.—(See Rate.)

SECONDARY MERIDIANS.—Those connected with the prime meridian by exchange of telegraphic time signals. Secondary meridians are determined with the utmost degree of care in order to locate with accuracy the positions of prominent points on the coasts. (See Tertiary Meridians.)

SEMICIRCULAR DEVIATION.—So called because it has the contrary name and maximum value in opposite semicircles; for instance, if it is westerly on north it will be easterly on south.

SEMIDIAMETER.—Half a diameter. The semidiameters of the sun and moon are given in the Nautical Almanac for every day of the year, but for purposes of practical navigation these may be called 16′. (See Corrected Altitude.)

SEND OF THE SEA.—(See Heave of the Sea.)

SENSIBLE HORIZON.—A plane which is tangent to the surface of the earth where the observer is situated. This plane extends north, south, east, and west until bounded by the sky. (See Visible Horizon.)

SET.—A heavenly body sets when its upper limb dips below

the horizon line , an altitude is set when the sliding limb of the sextant is clamped against the arc ; the space (span) contained between the points of the dividers in measuring a distance on the chart is known as a set ; to set the ship's course is to commence steering in the calculated direction ; the set of a current is the direction of its flow.

SEXTANT.—An instrument of reflection used by navigators for measuring the altitudes of heavenly bodies, and for observing angles. It is of more delicate mechanism than the quadrant or octant, and where the former is graduated (or cut, as it is often called) to minutes, and the latter to 15″ of arc, the sextant reads to 10″. The engraving in the front of the book represents the navigator's sextant.

Names of Various Parts.—A, the graduated arc ; the divisions of the arc are 10′ each, and these are subdivided by the vernier to 10″ ; H, the handle, by which the sextant is held in the right hand ; M, the mirror, or index-glass, at the end of the sliding limb ; *m*, the horizon-glass ; E, the magnifying telescope for giving greater distinctness to the images, is placed in the line of sight and supported in the ring or collar, K, which can be moved by a screw at the back in a direction at right angles to the plane of the sextant, so that the axis of the telescope may be directed either toward the silvered or transparent part of the horizon-glass ; the vernier is read by means of the magnifying-glass, R, attached to a revolving arm, S, which is secured upon the index bar or sliding limb ; P and Q, the colored shade-glasses, for shielding the eye from the glare of the sun ; P, the shades through which the image of the sun passes from the mirror to the horizon-glass ; Q, the back shade-glasses for protecting the eye from the glare of the horizon showing through the unsilvered part of the horizon-glass ; B, the tangent screw (set

tangent to the plane of the instrument) by which the vernier may be moved delicately along the arc after the sliding limb has been clamped by the screw C at the back ; I, the inverting telescope ; F, the simple tube without glasses for giving a direct line of sight from the centre of the telescope ring to the horizon-glass.

The inverting telescope, with its parallel wires, is principally used for measuring angular distances of heavenly bodies—a branch of nautical astronomy that does not come within the limits of this work. Altitudes may be measured by it in place of either of the other telescopes, but it requires considerable practice and a very steady hand. As its name implies, objects viewed through it appear upside down, so that to measure an altitude by it the navigator would bring the horizon down to the sun, instead of the sun down to the horizon.

The small key shown is for adjusting the horizon-glass, and the small ring beside it contains a colored glass, and this may be screwed on the eye end of the telescopes as a substitute for the shade-glasses.

The star telescope contributes illuminating power to an observation owing to its short tube and large object-glass, and permits the navigator to see the horizon distinctly when otherwise it would be obscured. If not provided with this valuable adjunct the navigator should have one fitted to his sextant, and be particular that its collimation adjustment is made perfect.

Adjustment of the Index-Glass.—This glass must be perpendicular to the plane of the sextant. To prove this, set the vernier to about the centre of the arc and clamp it, then look obliquely into the index-glass and observe if the arc seen direct and its reflection form one continuous line ; if so, the glass is perpendicular to the plane of the instrument, but if the reflected image appears to be lower than the other it proves that the glass

leans backward ; if, however, the reflected image appears to be higher than the other the glass leans forward.

Adjustment of the Horizon-Glass.—This glass must also be perpendicular to the plane of the sextant. To test this, let zero on the vernier cut zero on the arc, and hold the instrument almost horizontal, noting if the direct and reflected images of the horizon line coincide—that is, if they show as an unbroken line both in the silvered and clear parts of the glass. If they do, the horizon-glass is perpendicular, but if they do not, then adjust the glass to the required angle by the adjusting screw.

The Two Glasses to Be Parallel.—With the two zeros cutting, hold the instrument vertically, and if the direct and reflected images of the horizon line show as an unbroken and continuous line the horizon-glass is parallel to the index-glass, but if they do not show in an unbroken line adjust the horizon-glass by its adjusting screw.

To Find the Index Error.—Should it prove impossible to obtain a perfect adjustment find the error of the instrument as follows: let the two zeros cut, then holding the instrument vertically look at the horizon and gently finger the tangent screw so as to move the vernier either forward or backward along the arc until the image of and the horizon line itself show in an unbroken line across the glass ; then the difference between zero on the vernier and zero on the arc will be the index error, and the amount of same will be added to any altitude observed by the instrument if zero on the vernier is to the right hand (off the arc) of zero on the arc, but the amount will be subtracted if zero on the vernier is to the left hand (on the arc) of zero on the arc.

Telescope Adjustment.—Screw in the telescope containing the two parallel wires and see that they are turned until parallel

with the plane of the sextant; then select two stars, at least 90° apart, and make an exact contact at the wire nearest the plane of the instrument, and read the measured angle. Move the sextant so as to throw the objects on the other wire, and if the contact is still perfect the axis of the telescope is in its right situation and the telescope adjustment is correct. If the images have separated it shows that the object end of the telescope droops toward the plane of the sextant, and if the images overlap it proves that the object end of the telescope points away from the plane of the instrument. This will be rectified by the screws in the collar of the sextant. A defect in the telescope adjustment always makes angles too great. (See Axis of Collimation.)

Tormenting a Sextant.—The author desires to caution navigators against tormenting a sextant continually. A good instrument once placed in perfect adjustment (unless it meets with a heavy jar or fall) will keep in adjustment for a long time, and if let alone will give more satisfactory work than if the threads of the adjusting screws have become loose and worn from incessant slacking and setting up.

To Read the Sextant Altitude.—Ascertain by looking toward the left how many degrees and ten-minute divisions the vernier zero has passed on the arc, then look along the vernier to the left until one of its lines coincides exactly with one of the lines of the arc, and the number of vernier minutes and ten-second divisions given will be added to the degrees and minutes originally obtained on the arc, and the sum of the two will be the altitude. To this altitude will be applied the index error (if any exists) in order to obtain the corrected observed angle.

Remarks.—The quadrant, octant, and sextant are constructed on the same principle. Although the real arcs of these instru-

ments are respectively only 45°, 60°, and 70°, yet owing to their double reflection they measure angles of 90°, 120°, and 140°.

SHADE-GLASSES.—(See Sextant.)

SHADOW-PIN.—A straight, slender pin arranged to stand vertically on the centre of the glass of the compass bowl. It is portable and is set in place when required for the purpose of obtaining bearings of the sun. As its name indicates, it casts a shadow, and the opposite point of the compass from that on which the shadow falls is accepted as the bearing of the body. The shadow-pin may be employed for taking bearings generally, but it is not as satisfactory as an azimuth attachment or the pelorus.

SHAPING THE COURSE.—(See Chart Sailing; Great-Circle Sailing; Mercator's Sailing; Middle-Latitude Sailing.)

SHIP TIME.—The hour shown by the ship's clock, which is set to apparent time or solar time. This may be done roughly by turning the hands of the clock to twelve (noon) when the sun crosses the meridian, or by allowing for the number of miles sailed east or west since the clock was last set. To accomplish this simply add to the face of the clock four minutes of time for every degree sailed east and subtract four minutes for every degree sailed west since the clock was last set on solar time. The most correct way is to proceed according to the rule given under the head of Regulating.

SHORE RATE.—(See Rate.)

SIDEREAL.—Relating to the stars.

SIDEREAL DAY.—The interval between two successive transits of the same star over the same meridian; the period of time in which the earth performs a complete revolution on its

axis. The length of a sidereal day is 23 h. 56 m. 04 sec., so that a sidereal day is shorter than a mean solar day by 3 m. 56 sec.

SIDEREAL NOON.—This occurs when the First Point of Aries comes to the meridian.

SIDEREAL TIME.—Time measured by the stars. Sidereal time commences when the First Point of Aries is on the meridian and is counted from one hour to twenty-four hours, when the same point returns to the meridian again.

SIGHT.—To take a sight is to measure the altitude of a heavenly body.

SLIDING LIMB.—(See Sextant.)

SLIP OF WHEEL.—The difference between the speed shown by a steam vessel and the speed that would be attained provided the propeller or paddle-wheels acted upon a solid substance in place of a fluid. Slip of wheel is often referred to as the lost motion of the propeller. It is customary to allow a certain number of revolutions to the mile, and according to this the estimated distance run by the vessel is compared with the actual distance run by observation, and the difference, expressed as a per centum, is entered in the log-book under the head of slip of wheel. Head winds and seas often retard a vessel's speed so that the slip of wheel reaches 50 per cent. and more.

SOLAR.—Relating to the sun.

SOLAR DAY.—The time which elapses between two successive transits of the sun over the same meridian.

SOLAR SYSTEM.—The sun and the heavenly bodies revolving around it; namely: Mercury, Venus, Earth, Moon, Mars, Jupiter, Saturn, Uranus, and Neptune.

SOLAR TIME.—Time measured by the sun. When the sun

crosses the meridian of the observer it is apparent noon at his place.

SOLSTICES.—Those times of the year when the sun is at its greatest distance from the equator ; when its declination is 23½° north or 23½° south.

SPECULUM.—A mirror ; the reflecting glass on an azimuth attachment.

SPHERE.—According to geography, a representation of the earth's surface, and according to astronomy, the celestial concave.

SPHERICAL.—Globular.

SPHERICAL SAILINGS.—Great-Circle, Mercator, Middle-Latitude and Parallel Sailings.

SPHERICAL TRIANGLE.—A portion of the surface of a sphere, contained by the arcs of three great circles.

SPHERICAL TRIGONOMETRY.—That branch of trigonometry which deals with the method of solving spherical triangles.

SPIRIT COMPASS.—A liquid compass.

SPRING EQUINOX.—When the sun crosses the equator from southern into northern declinations. This is known as the First Point of Aries. The Spring Equinox is often referred to as the Vernal Equinox. (See First Point of Aries.)

STANDARD COMPASS.—One of the ship's compasses placed where it is least influenced by deviation, and by which the vessel is navigated.

STANDARD TIME.—Time shown by a watch or clock set to mean solar time. (See Mean Sun.)

STARS.—(See Fixed Stars.)

STAR TELESCOPE.—(See Sextant.)

STAR TIME.—Same as sidereal time.

STATION POINTER.—An instrument made use of in marine surveying. It consists of a circle of brass graduated in degrees, and is provided with one fixed and two movable arms which project from its centre, so that the former may be set to any required angle. It is used sometimes on board ship when sailing along the coast, so as to locate the vessel's position by observing bearings of objects on shore. (See Telemeter.)

STATUTE MILE.—(See Mile.)

STEERING COMPASS.—That particular compass referred to by the wheelsman in steering the ship. The vessel is placed on her course by the standard compass, then whatever point is indicated at the time by the steering compass shows the course for the wheelsman to keep the vessel on according to that compass.

STELLAR.—Relating to the stars.

SUB-PERMANENT MAGNETISM.—After a new iron ship has been launched, it has been found that the magnetism induced in the hull while building rapidly diminishes, but by no means departs entirely, and that which remains is called sub-permanent magnetism.

SUMNER'S METHOD.—A process employed for finding by a chronometer observation of the sun, or other heavenly body, the true latitude and longitude of the ship, especially when the latitude by dead reckoning cannot be relied upon. This is one of the most valuable problems within the sphere of the navigator, and should be practised by him until proficiency is

attained. In reality it consists of simply working out the longitude several times by either the sun or the moon, a planet or fixed star. In the following we will consider that the sun is employed, consequently the longitudes will be ascertained according to the rule given under the head of "Longitude by One Altitude of the Sun." In case this problem is worked by the moon or by a planet or a star, then the longitudes will be found according to the respective rules given for those bodies under the head of Longitude; but the lines on the chart will be drawn and the position of the vessel plotted in precisely the same way as described below for the sun. This problem in character is similar to and its result the same as that derived from what is known as the Combined Altitude Problem, or the Double Altitude Problem, but it employs fewer figures and as a natural consequence is simple in comparison and more easily worked than the other.

Rule.—Assume two latitudes, one 30′ (miles) less, and the other 30′ greater than the latitude by dead reckoning, then observe a regular time sight of the sun and work it up as usual, employing either of the assumed latitudes, and mark the result on the chart. Now work the same sight over again, using the other assumed latitude. Mark this answer also on the chart and draw a pencil line from one dot to the other. This is known as a line of bearing, and the ship will be somewhere on this line.

The next thing required is to locate the vessel on this line of bearing. To effect this wait until the sun has changed its azimuth (bearing) at least 2½ points (four or more would be better) then observe another regular time sight and work it up twice as before, making use of the same two assumed latitudes. Mark these two results on the chart and connect them also with a pencil line, which call the second line of bearing. It will be

seen that the first and second pencil lines cross one another. Now this intersection points out the ship's place provided she has remained stationary between observations, but if not, then the course and distance sailed after the first observation was taken must be considered as follows:

Lay off (in pencil) from any part of the first line of bearing the true course and distance sailed in the interval between sights, and through the termination of this course and distance draw a line parallel to the first line of bearing, and where this last line drawn intersects the second line of bearing will be the ship's place.

Remarks.—Instead of using assumed latitudes 30′ different from the latitude by account, the navigator may extend this amount to 1° if he so prefers.

When the first line is drawn on the chart for the purpose of connecting the first two pencil dots, the navigator knows that he is somewhere on this line, and provided the line is not parallel to the coast, its extension will run into the land, so that if the ship is headed to sail on this line of bearing toward the coast, she will ultimately reach the point into which the line runs. The same applies as well to the second line of bearing.

It has already been explained that when the second line of bearing has been drawn on the chart, the ship's place is fixed.

This problem has been styled by some navigators as an astronomical cross-bearing.

SUN.—The centre of the solar system: diameter, 885,000 miles; mean distance from the earth, 95,000,000 miles; mean apparent diameter, 32′; circumference, 2,780,000 miles.

SUN DOG.—A luminous spot occasionally seen in the heavens near the sun.

SUNRISE AND SUNSET SIGHTS.—(See Longitude.)

SUN TIME.—Same as solar time.

SWINGING SHIP.—When the vessel is turned in a circle so that her head is brought consecutively to the thirty-two points of the compass, the operation is known as swinging ship. This is performed in compass-adjusting, the purpose being to note, while on each point, the compass-bearing of some distant but well-defined object, the correct magnetic bearing of which is known.

SYMBOLS.—(See Log Book.)

TAFFRAIL LOG.—A patent log, the register of which secures to the taffrail. (See Patent Log.)

TAKING DEPARTURE.—(See Departure.)

TANGENT SCREW.—(See Sextant.)

TELEMETER.—An instrument consisting of two parallel base bars, divided by scales to tenths of an inch and ranging from 0 to 20 inches on each bar. The object of this instrument is to mechanically solve problems that involve the parts of a plane triangle. It is only of use when sailing along the coast, when it affords a ready means of locating the ship by observing shore bearings, such as light-houses, prominent headlands, etc.

TELL-TALE.—An inverted compass suspended from overhead in the cabin, or elsewhere below.

TERRESTRIAL.—Relating to the earth.

TERTIARY-MERIDIANS.—Those connected with secondary meridians by carrying time in the most careful manner. (See Secondary Meridians.)

THERMOMETER.—An instrument used for measuring

the variations of temperature. Fahrenheit's thermometer is a mercurial column so graduated as to have 180° between the freezing and boiling points of water. The freezing point of water on this thermometer is 32°, and the boiling point 212°. To indicate degrees below zero, it is common to preface them with the minus (—) sign. A Centigrade thermometer is a mercurial column so graduated as to have 100° between the freezing and boiling points of water, zero being the freezing point.

To reduce Centigrade reading to Fahrenheit, multiply by 9, divide by 5 and add 32.

To reduce Fahrenheit to Centigrade, subtract 32, multiply by 5 and divide by 9.

TIME.—(See Apparent, Astronomical, Civil, Greenwich, Local-Apparent, Mean, Mean-Solar, Ship, Sidereal, Solar, Standard, Star, and Sun Times. See also Equation of Time.)

TIME COURSE.—During fog, while navigating in waters where it is necessary to change the course at certain fixed points in order to keep in the channel, or to avoid danger, the employment of time courses becomes imperative. In order to run these, the course and distance from point to point is measured on the chart, and the speed of the vessel taken into account. As soon as the calculated period of time has expired, it is considered that the required distance has been run, and the course is accordingly changed.

If there is a current flowing with, or against, or across the ship's course, the same must be allowed for.

When threading coral reefs that are submerged, time courses are often employed.

TIME SIGHT.—An observation of a heavenly body taken for the purpose of ascertaining the longitude. (See Longitude.)

TRANSIT.—The passage of a heavenly body across the meridian. (See Lower Transit; Upper Transit.)

TRAVERSE.—An irregular track made by a vessel on account of having sailed several courses.

TRAVERSE SAILING.—(See Traverse.)

TRAVERSE TABLES.—Tables containing the difference of latitude and departure for quarter points and for single degrees of the compass, calculated for intervals of one mile and extending to three hundred miles. By these tables the solution of right-angle triangles is accomplished by mere inspection. The form that a navigator rules for working out his dead reckoning is a traverse table for the particular courses sailed by his vessel.

TRIGONOMETRY.—The science of measuring triangles.

TRIPOD COMPASS.—A compass elevated on a three-leg stand, on the principle of the pole compass.

TROPIC OF CANCER.—The parallel of 23° 28′ north—the highest northern point of the sun's declination, which it reaches on June 21st.

TROPIC OF CAPRICORN.—The parallel of 23° 28′ south—the highest southern point of the sun's declination, which it reaches on December 21st.

TRUE-CENTRAL-ALTITUDE.—(See Corrected Altitude.)

TYPHOON.—(See Law of Storms.)

UPPER LIMB.—The highest part of the circumference of the sun and moon; the part situated directly above the centre. When the image of the lower portion of the disk of the sun or moon is brought in contact with the horizon, it is said that the

altitude of the lower limb is observed, and when the image of the upper portion of the disk is brought in contact with the horizon, it is said that the altitude of the upper limb is observed. (See Corrected Altitude.)

UPPER TRANSIT.—The passage of a heavenly body over the meridian when the body is moving from east to west. The Nautical Almanac gives the astronomical times of the upper transits of heavenly bodies. The body having risen until it crossed the meridian above the pole, while moving from east to west, it declines to the west, then curves eastward, continuing to fall until it crosses the meridian below the pole—180° distant from the meridian of its upper transit. It then commences to rise, still moving eastward, and when midway between the meridians of its upper and lower transits, it curves westward and continues to rise until it again makes its upper transit. (See Lower Transit.)

VARIATION.—The divergence of the compass needle from the true north of the heavens. This is not constant. In the year 1663 in Paris, the needle pointed true north, previous to which the variation had been easterly. From the year 1663 to the year 1814, the westerly variation in Paris steadily increased, until in the latter year it amounted to 22½°. From the year 1814 it has steadily decreased, but is still westerly. (See Compass; Amplitude; Azimuth.)

VARIATION CHART.—(See Chart.)

VERNAL EQUINOX.—(See Spring Equinox.)

VERNIER.—The graduated scale on the sliding limb or index bar of the sextant. (See Sextant.)

VERTEX.—That point of the heavens situated perpendicu-

larly above the observer's head ; the angular point, or the point where the two legs or sides of an angle meet.

VERTICAL.—Perpendicular to the horizon.

VERTICAL CIRCLE.—A great circle of the sphere which passes through the zenith and nadir of a place.

VERTICAL DANGER ANGLE.—(See Danger Angle.)

VISIBLE HORIZON.—The boundary or limit of the observer's view is termed the visible or apparent horizon. The angle between the sensible and visible horizons is known as the dip of the horizon.

WATCHES.—(See Log-Book.)

WEATHER.—The signs or indications by which the coming weather may be anticipated are as follows :

A rosy sky at sunset, fine weather ; a bright yellow sky at sunset, wind ; a pale yellow sky at sunset, wet ; orange or copper colored sky, wind and rain ; sickly greenish hue, wind and rain ; tawny or coppery clouds, wind ; a dark red sky, rain ; a red sky in the morning, bad weather ; a gray sky in the morning, fine weather ; a high dawn, wind ; a low dawn, fair weather ; soft or delicate clouds, fine weather with light breezes ; hard-edged, oily looking clouds, wind ; a dark, gloomy, blue sky, wind ; light, bright-blue sky, fine weather ; light, delicate tints with soft, indefinite forms of cloud, fine weather ; gaudy or unusual hues with hard, definitely outlined clouds, rain and wind ; small, inky clouds, rain ; high upper clouds crossing the heavens in a direction different from that of the lower clouds, or of the wind felt below, foretell a change of wind in the direction of the upper clouds ; when sea birds fly out far to seaward, moderate wind and fair weather may be expected ; when sea

birds hang about the land or fly inland, strong winds and stormy weather are promised; dew is an indication of coming fine weather.

Cirrus.—Also known as the *mare-tail cloud,* composed of streaks, wisps, and fibres; a cloud of the least density and greatest elevation, showing the widest range of direction and variety of form. Settled weather is to be expected when groups of cirri are to be seen during a gentle wind after severe weather has been experienced. When streaks of cirri extend across the sky conforming to the direction in which a light wind is blowing, the wind will remain steady but increase. When fine threads of cirri are blown or brushed backward at one end, the surface wind will veer around to that point.

Cumulus.—This is also known as the *day cloud* and the *summer cloud.* It forms only in the day-time during the summer, and results from the rise of vapors from rivers, lakes, etc., into the colder atmosphere. Fine, calm, and warm weather may be anticipated when cumuli take on a moderate size and delicate color; but cold, rainy, and heavy weather may be expected when cumuli in dense, dark masses roll acress the sky, sink lower, and do not disappear at sunset.

Stratus.—Also called the *night cloud.* It hangs the lowest of the various clouds, obtains its greatest density about midnight, and disappears when the sun rises. It is formed by the condensation of vapors from lakes, marshes, etc., appearing as an extended sheet of white mist near to the earth, and sometimes touching it.

Cirro-Cumulus.—This is known as well by the name of a *mackerel sky.* It is seen in small, rounded masses, looking like flocks of sheep lying down, and in consequence is referred to at times as *sheep-in-a-meadow sky.* It is principally seen in summer,

and indicates warm, dry, weather. When cirro-cumulus occurs in winter, a thaw and wet weather may be expected.

Cirro-Stratus.—Also referred to as the *vane cloud*, the *shoal of-fish cloud*, and the *mackerel-backed cloud*. A storm of rain or snow may be expected when this cloud is seen. As it name signifies, this cloud exhibits a mingling of the characteristics of the cirrus and stratus, being dense in the middle and tapering toward the edges.

Cumulo-Stratus.—A blending or mingling of the cumulus and cirro-stratus, appearing at times as a thick bank of cloud with overhanging edges. What is known as a *distinct-cumulo-stratus cloud* appears as a cumulus cloud surrounded on all sides by small fleecy clouds. When cumulo-stratus clouds are seen sudden atmospheric changes may be expected.

Nimbus, or Cumulo-Cirro-Stratus.—Called the *rain cloud*. As it name signifies, it is a combination of the three primary forms of cloud. The cirro-stratus overspreads the sky, and underneath it the cumulus clouds drive in from windward until they form one continuous mass, settling down in a horizontal sheet from which rain falls.

Cloud Scale.—The amount of cloud is denoted by a numerical scale of 0 to 10—0 indicating a clear sky, 5 a sky half covered, and 10 a totally obscured sky.

Rainbows.—When rainbows are observed in the morning they promise wet weather, but when observed in the evening they promise clear weather.

WIND.—The wind, as a rule, shifts with the sun; but whereas this means from left to right (or with the hands of a clock) in the northern hemisphere, it means from right to left (or against the hands of a clock) in the southern hemisphere. This is known as *veering*. When the wind shifts in the contrary

direction it is known as *backing*. There is an old sea couplet which applies with truthfulness to the shifting of the wind :

"When the wind shifts against the sun,
Trust it not, for back it will run."

In the northern hemisphere the *veering*, or proper shifting of the wind would be from east to west by the way of south-east, south, and south-west, and the *backing* of the wind would be from east to west by the way of north-east, north, and north-west.

In the southern hemisphere the above rule would be reversed.

When the wind *backs* it may be accepted as a sign that the weather is unsettled, and that the wind will come out again from its original quarter.

Winds are named from the direction in which they blow, hence a north wind comes out of the north.

ZENITH.—That point in the heavens vertically overhead of the observer, and 90° distant from every point of the horizon. Opposed to nadir. (See Nadir.)

ZENITH DISTANCE.—What an altitude lacks of 90°, or the complement of an altitude ; the angular distance of a heavenly body from the zenith of the observer.

ZERO.—The point at which the cutting or graduation of a sextant, etc., commences.

ZODIAC.—An imaginary zone in the celestial concave in which the sun, moon, and larger planets appear to perform their revolutions.

ZONE.—There are five zones : the torrid zone extending

from the equator to 23° 28′ north and south; the temperate zones extending from 23° 28′ north and south to 66° 32′ north and south, and the frigid zones extending from 66° 32′ north and south to the poles.

ADDENDA.

ARC INTO TIME AND VICE VERSA.—To reduce longitude (arc) into time, and time into longitude, the use of Table 7, Bowditch, is recommended. In the first column of said table the degrees of longitude are found at the top marked D, and the minutes of longitude underneath marked M. In the adjoining column to the right is found the corresponding time—hours marked H on top and minutes of time marked M underneath. The explanation of this is that when the arc column is used for degrees, the answer opposite in the time column is given in hours and minutes; but when the arc column is used for minutes of longitude the answer opposite in the time column is given in minutes and seconds.

If the arc column is used for seconds of longitude, the answer opposite in the time column is given for seconds and sixtieths of seconds.

To convert time into longitude (arc) apply the hours under H in the time column, and opposite to the left in the arc column will stand the value in degrees. Next put the minutes of time under M in the time column and opposite to the left in the arc column will stand the value in minutes of arc.

If one second of time is left over, its value in arc is 15″; if two seconds of time are left over, their value in arc is 30″, and if three seconds of time are left over, their value in arc is 45″. (See Correcting Time; Chronometer; Ship's Time; Regulating; Time.)

BACKING AND FILLING PROBLEM.—After taking a morning sight for longitude, the figures are held for the time being, as it is not considered possible to work the problem at once with any reliance upon the result owing to the latitude by dead reckoning being in doubt. Therefore, the course and distance sailed by the ship in the interval between the morning sight and noon are carefully noted so that the navigator may work back by dead reckoning from his noon latitude by observation to the lati-

tude his ship was in at the time of the morning altitude. Having done this, his morning longitude may be worked out, and then brought forward to noon by dead reckoning. It is this going backward and bringing forward that gives the name to this style of problem. The first thing to do is to work out the noon latitude, then the latitude of the ship at the time of the morning sight, then the longitude at the time of the morning sight, and then bring the latter forward to noon.

CHART SAILING.—On page 25, under the head of *Cross Bearings* it refers to the conversion of compass bearings (where deviation exists) into correct magnetic bearings. This is done by applying to the two bearings respectively the amount of deviation existing for the *ship's head* at the time the bearings were taken. To effect this simply allow westerly deviation around the compass contrary to the way the hands of a watch revolve, and easterly deviation with the hands of a watch. By applying the given amount of deviation in this way the compass bearings will be converted into correct magnetic bearings, and these will be plotted on the chart.

For example, suppose a light-house bears N. by compass and there is one point of westerly deviation to allow for; in this case the correct magnetic bearing will be N. by W., which, in other words, is the way the light-house would bear by the ship's compass if there was no deviation.

On the other hand, if there was one point of easterly deviation to allow for, then the correct magnetic bearing of the light-house would be N. by E.

CHRONOMETER TO SHIP'S TIME.—To find the mean time at the ship from the chronometer or Greenwich time, proceed as follows:

By the use of Table 7 turn the ship's longitude into time, then add same to the face of the chronometer if in east longitude, but subtract it if in west longitude, and the answer will be the local mean time at the ship.

If the local apparent time at the ship is required, simply apply the equation of time for the given day according to the directions given in the Nautical Almanac. (See Regulating, Time.)

CORRECTING TIME.—When the ship changes her longitude she changes her time, and the method of estimating this change is as follows:

Note the compass course and distance sailed since the clock was last set, and convert said course into a true course by applying leeway, variation and deviation; then from the table select the departure made for said course and distance and turn this departure into longitude according to the parallel of the ship. Next multiply this change of longitude by 4, which will reduce it to seconds of time, then apply this change of time to the face of the clock, adding if the ship has sailed east, but subtracting if she has sailed west, and the answer will be the time of the meridian the ship is on. Sailing north or south does not change time. (See Regulating, Time.)

DEAD RECKONING.—In seeking in Tables 1 or 2 for the distance run on a certain course, if the number of miles exceed the figures in the distance column (which extend to 300 miles only) then take out the latitude and departure for half the distance run, and multiply the same by 2.

On the same principle, when seeking to find the course and distance made good, if the difference of latitude and departure are too great for comparison, point off a place in each, which will reduce the quantities to one-tenth of their values, then make the comparison as usual, and multiply the number of miles given by 10; but do not multiply the course angle, for the same has been preserved by reducing the difference of latitude and departure proportionately.

LATITUDE BY THE POLE STAR.—The way to find the latitude of the ship by the Pole Star, using what is commonly called the "clock method," is fully treated in this book on page 76. The "chronometer method" is as follows:

Observe an altitude at any hour when the star can be seen, note the chronometer and convert same into astronomical time. To this latter apply the ship's longitude in time, adding it if in east longitude but subtracting it if in west, and the answer will be the astronomical mean time at ship. To this add the correction from Table 3, nautical almanac, then to this sum add the right ascension of the mean sun for the given day, which will show the local sidereal time. This applied to the almanac constant will give the hour angle. Next correct the altitude for dip and refraction, then apply to the remainder the correction given for the star's hour angle, and the answer will be the latitude of the ship.

LEAD AND LINE.—The hand-lead is about 10 inches in length, tapering to its upper end where the line is bent in, and weighs about 10 pounds. The line measures 25 fathoms (150 feet), and this instrument is employed for taking soundings in water of 20 fathoms and under—the other 5 fathoms being surplus line. The lead has 9 marks and 11 deeps—the latter being the unmarked fathoms of the line. The following shows the manner of marking:

At 2 fathoms from the lead, 2 strips of leather.
At 3 " " " 3 strips of leather.
At 5 " " " piece of white bunting.
At 7 " " " piece of red bunting.
At 10 " " " leather with a hole in it.
At 13 " " " piece of blue bunting.
At 15 " " " piece of white bunting.
At 17 " " " piece of red bunting.
At 20 " " " strand with two knots.

LONG DAY.—Should a vessel sail from port early in the morning and get clear of land and be on her course before noon, it is customary with the navigators to make no attempt to work out the position of the ship until the following noon. This insures more than a 24 hours' reckoning, and is referred to as a *long day's work.* On the other hand, if the vessel leaves port in the afternoon, her position worked out the next day at meridian would be short of 24 hours, and would be called a *short day.*

In sailing east, also, the ship advances to meet the sun, thus shortening the day, while the opposite effect is realized in sailing west. (*See Circumnavigators' Day.*)

MERCATOR'S SAILING.—When seeking to compare the meridional difference of latitude and the difference of longitude, if the figures of same exceed those in the tables, point off one or more places so as to reduce them to the table limits, and this will not change the course-angle because you point off as much of one quantity as you do of the other. If the proper difference of latitude is too large for the latitude column, point off one place or more; but be sure to multiply the figures obtained for the distance accordingly.

MIDDLE LATITUDE SAILING.—Strictly speaking, when the course of the ship crosses the equator, the course should be worked for each side of the Line, in order to obtain the correct middle latitude for use in converting the difference of longitude into departure.

When the difference of latitude and the departure exceeds the table limits, proceed as explained in this ADDENDA under the head of *Dead Reckoning*.

SHORT DAY.— (See LONG DAY.)

SUNRISE AND SUNSET.—The apparent time of sunrise and sunset is found in the *azimuth tables* published by the United States Navy Department, also by Burdwood and Davis, for various latitudes and declinations of the sun, and in order to reduce this time to mean, or shore time, it is necessary to apply the equation of time given in the Nautical Almanac for the date in question.

To calculate the time of sunrise and sunset, independent of azimuth-table aid, proceed as follows : Add together the logarithms tangent of the ship's latitude and tangent of the sun's declination. The result will be the logarithm cosine in apparent time, and if the latitude and declination are of different names, it will be the apparent time of sunset, and subtracted from 12 hours it will be the apparent time of sunrise. If the latitude and declination are of the same name the cosine time will be the apparent time of sunrise, and subtracted from 12 hours the apparent time of sunset. To convert this time into mean time, apply the equation of time for the given date, as directed in the Nautical Almanac.

It is to be understood that the foregoing rule gives the time of the sun's centre on the horizon, considering the observer's eye to be at the level of the sea, and without being influenced by refraction. In order to find the time of the sun's rising and setting with the refraction and dip allowed for, add together the logarithms secant of the ship's latitude, secant of the sun's declination, cosecant of the hour angle at rising or setting, and the sine of 34′ plus the dip given in Table 14 for the height of the observer's eye above the sea level. The sum of these logarithms is the log sine of the small portion of time between the true and apparent hour angles, and this amount must be applied to the hour angle first found.

TIDES.—To find the approximate time of high water at any place, is a simple calculation. Select from the Nautical Almanac the time of the moon's meridian passage at Greenwich and correct it for the ship's longitude east or west of Greenwich by the use of Table 11. Now, to this time of the moon's passage over the meridian of the ship add the tide-hour from Tables either 46 or 47—the first for places on the coasts of the United States and the latter for foreign coasts—and the answer will be the time of high water at the given place.

TIME INTO ARC.—(See Arc into Time.)

TRUE AZIMUTH BY LOGARITHMS.—Convert the observed altitude into a true altitude, then find the polar distance. Next add together the polar distance, true altitude and the latitude by dead reckoning, divide their sum by 2, and call the result the half sum, from which subtract the polar distance, and note the remainder. Select the secant of the true altitude, secant of the latitude, cosine of the half sum, and cosine of the remainder The half sum of these four logs will be named cosine, and the same will be looked for in Table 44. The degrees and minutes of arc given for the cosine—whether found from top or bottom of page—must be multiplied by 2 to obtain the true azimuth.

In selecting the degrees for the log cosine, whether found from the top or bottom of page, take the smallest number of degrees, and use the minute column belonging to same.

TO INTERPOLATE SPECIAL LOGARITHMS.—It is to be explained that the method of interpolation by inspection, as explained on page 85, is not available in that portion of the table where the logarithmic differences vary so rapidly that no values will apply alike to all the angles on the same page, therefore, on such pages (for example, 0°, 1°, 2°, 3°, 4°, 85°, 86°, 87°, 88°, 89°, 90°, 91°, 92°, 93°, 94°, 175°, 176°, 177°, 178°, and 179°), the difference for one minute is given in a column headed DIFF. 1′ instead of the usual difference for each second. In these cases the interpolation must be made by computation. The column difference for 1′ must be divided by 60 to get the figures for 1″, then these figures must be multiplied by the number of seconds of the angle to obtain the correction, and this will be applied as heretofore directed on page 85. When using the left hand minute column of the table, the DIFF. FOR 1′ will be selected directly opposite the minutes of the angle; but when using the right hand minute column, the DIFF. FOR 1′ will be selected from the line next above the minutes of the angle.

TO SUBSTITUTE TABLE 27.—Bowditch having substituted a new and less desirable Table 27, a reprint of the old one, under the caption of Square of Time Table, has been added in the back of this book for the benefit of the navigator.

PATTERSON'S TABLE OF CORRECTION

1907–1908 TO BE APPLIED TO THE **1909–1910**

TRUE ALTITUDE OF THE POLAR STAR.

R. A. of Meridian.	Alt. Correction.	R. A. of Meridian.	Alt. Correction.	R. A. of Meridian.	Alt. Correction.	R. A. of Meridian.	Alt. Correction.
h. m.	° ′	h. m.	° ′	h. m.	° ′	h. m.	° ′
0 0	−1 06	6 10	−0 22	12 10	+1 06	18 10	+0 24
0 10	−1 06	6 20	−0 19	12 20	+1 07	18 20	+0 21
0 20	−1 07	6 30	−0 16	12 30	+1 08	18 30	+0 18
0 30	−1 08	6 40	−0 13	12 40	+1 08	18 40	+0 15
0 40	−1 08	6 50	−0 10	12 50	+1 09	18 50	+0 12
0 50	−1 09	7 00	−0 07	13 00	+1 10	19 00	+0 09
1 00	−1 10	7 10	−0 03	13 10	+1 10	19 10	+0 06
1 10	−1 10	7 20	0 00	13 20	+1 11	19 20	+0 03
1 20	−1 11	7 30	+0 02	13 30	+1 11	19 30	0 00
1 30	−1 11	7 40	+0 05	13 40	+1 11	19 40	−0 03
1 40	−1 11	7 50	+0 08	13 50	+1 10	19 50	−0 06
1 50	−1 11	8 00	+0 11	14 00	+1 10	20 00	−0 10
2 00	−1 10	8 10	+0 15	14 10	+1 10	20 10	−0 13
2 10	−1 10	8 20	+0 18	14 20	+1 09	20 20	−0 16
2 20	−1 09	8 30	+0 20	14 30	+1 08	20 30	−0 19
2 30	−1 08	8 40	+0 23	14 40	+1 07	20 40	−0 22
2 40	−1 07	8 50	+0 26	14 50	+1 07	20 50	−0 25
2 50	−1 06	9 00	+0 29	15 00	+1 05	21 00	−0 28
3 00	−1 05	9 10	+0 32	15 10	+1 04	21 10	−0 30
3 10	−1 04	9 20	+0 35	15 20	+1 03	21 20	−0 33
3 20	−1 02	9 30	+0 37	15 30	+1 01	21 30	−0 36
3 30	−1 01	9 40	+0 40	15 40	+0 59	21 40	−0 39
3 40	−0 59	9 50	+0 42	15 50	+0 58	21 50	−0 41
3 50	−0 58	10 00	+0 45	16 00	+0 56	22 00	−0 44
4 00	−0 55	10 10	+0 47	16 10	+0 54	22 10	−0 46
4 10	−0 53	10 20	+0 49	16 20	+0 52	22 20	−0 48
4 20	−0 51	10 30	+0 51	16 30	+0 50	22 30	−0 51
4 30	−0 48	10 40	+0 54	16 40	+0 48	22 40	−0 53
4 40	−0 46	10 50	+0 55	16 50	+0 45	22 50	−0 55
4 50	−0 43	11 00	+0 57	17 00	+0 43	23 00	−0 57
5 00	−0 41	11 10	+0 59	17 10	+0 40	23 10	−0 59
5 10	−0 38	11 20	+1 01	17 20	+0 38	23 20	−1 00
5 20	−0 36	11 30	+1 03	17 30	+0 35	23 30	−1 03
5 30	−0 34	11 40	+1 04	17 40	+0 32	23 40	−1 03
5 40	−0 31	11 50	+1 05	17 50	+0 30	23 50	−1 06
5 50	−0 28	12 00	+1 06	18 00	+0 27	24 00	−1 06
6 00	−0 25	* *	* *	* *	* *	* *	* *

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Yards.	Height of Light Above Sea-Level.			
	30 Feet.	35 Feet.	40 Feet.	45 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
100.......	5 42 40	6 39 20	7 35 40	8 31 50
150.......	3 48 50	4 26 50	5 04 50	5 42 40
200.......	2 51 40	3 20 20	3 48 50	4 17 20
250.......	2 17 30	2 40 20	3 03 10	3 26 00
300.......	1 54 30	2 13 40	2 32 40	2 51 40
350.......	1 38 10	1 54 30	2 10 50	2 17 10
400.......	1 26 00	1 40 10	1 54 30	2 08 50
450.......	1 16 20	1 29 10	1 41 50	1 54 30
500 (¼ m.).	1 08 40	1 20 10	1 31 40	1 43 10
550.......	1 02 30	1 12 50	1 23 20	1 33 40
600.......	0 57 20	1 06 50	1 16 20	1 26 00
650.......	0 52 50	1 01 40	1 10 30	1 19 20
700.......	0 49 10	0 57 20	1 05 30	1 13 40
750.......	0 45 50	0 53 30	1 01 10	1 08 40
800.......	0 43 00	0 50 10	0 57 20	1 04 30
850.......	0 40 30	0 47 10	0 53 50	1 00 40
900.......	0 38 10	0 44 30	0 51 00	0 57 20
950.......	0 36 10	0 42 10	0 48 10	0 54 20
1000 (½ m.)	0 34 20	0 40 10	0 45 50	0 51 30

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Yards.	Height of Light Above Sea-Level.			
	30 Feet.	35 Feet.	40 Feet.	45 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
1050......	0 32 40	0 38 10	0 43 40	0 49 10
1100......	0 31 10	0 36 30	0 41 40	0 46 50
1150......	0 29 50	0 34 50	0 39 50	0 44 50
1200......	0 28 40	0 33 20	0 38 10	0 43 00
1250......	0 27 30	0 32 00	0 36 40	0 41 10
1300......	0 26 30	0 30 50	0 35 20	0 39 40
1350......	0 25 30	0 29 00	0 34 00	0 38 10
1400......	0 24 30	0 28 40	0 32 40	0 36 50
1450......	0 23 40	0 27 40	0 31 40	0 35 30
1500 (¾ m.)	0 22 50	0 26 40	0 30 30	0 34 20
1550......	0 22 10	0 25 50	0 29 30	0 33 20
1600......	0 21 30	0 25 00	0 28 40	0 32 10
1650......	0 20 50	0 24 20	0 27 50	0 31 10
1700......	0 20 10	0 23 30	0 27 00	0 30 20
1750......	0 19 40	0 22 50	0 26 10	0 29 30
1800......	0 19 10	0 22 20	0 25 30	0 28 40
1850......	0 18 30	0 21 40	0 24 50	0 27 50
1900......	0 18 10	0 21 10	0 24 10	0 27 10
1950......	0 17 40	0 20 30	0 23 30	0 26 30
2000 (1 m.)	0 17 10	0 20 00	0 22 50	0 25 50

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea Level.		
	50 Feet.	55 Feet.	60 Feet.	65 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	4 45 50	5 14 10	5 42 40	6 11 00
0.2.......	2 23 10	2 37 30	2 51 40	3 06 00
0.3.......	1 35 30	1 45 00	1 54 30	2 04 00
0.4.......	1 11 40	1 18 50	1 26 00	1 33 00
0.5.......	0 57 20	1 03 00	1 08 40	1 14 30
0.6.......	0 47 40	0 52 30	0 57 20	1 02 00
0.7.......	0 40 50	0 45 00	0 49 10	0 53 10
0.8.......	0 35 50	0 39 20	0 43 00	0 46 30
0.9.......	0 31 50	0 35 00	0 38 10	0 41 20
1.0.......	0 28 40	0 31 30	0 34 20	0 37 10
1.1.......	0 26 00	0 28 40	0 31 10	0 34 00
1.2.......	0 24 00	0 26 20	0 28 40	0 31 00
1.3.......	0 22 00	0 24 10	0 26 30	0 28 40
1.4.......	0 20 30	0 22 30	0 24 30	0 26 40
1.5.......	0 19 10	0 21 00	0 22 50	0 24 50
1.6.......	0 17 50	0 19 40	0 21 30	0 23 20
1.7.......	0 16 50	0 18 30	0 20 10	0 21 50
1.8.......	0 15 50	0 17 30	0 19 10	0 20 40
1.9.......	0 15 00	0 16 30	0 18 10	0 19 40
2.0.......	0 14 20	0 15 40	0 17 10	0 18 40

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	70 Feet.	75 Feet.	80 Feet.	85 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	6 39 20	7 07 30	7 35 40	8 03 50
0.2.......	3 20 20	3 34 30	3 48 50	4 03 10
0.3.......	2 13 40	2 23 10	2 32 40	2 42 10
0.4.......	1 40 10	1 47 20	1 54 30	2 01 40
0.5.......	1 20 10	1 26 00	1 31 40	1 37 20
0.6.......	1 06 50	1 11 40	1 16 20	1 21 10
0.7.......	0 57 20	1 01 20	1 05 30	1 09 30
0.8.......	0 50 10	0 53 40	0 57 20	1 00 50
0.9.......	0 44 30	0 47 40	0 51 00	0 54 10
1.0.......	0 40 10	0 43 00	0 45 50	0 48 40
1.1.......	0 36 30	0 39 00	0 41 40	0 44 20
1.2.......	0 33 20	0 35 50	0 38 10	0 40 30
1.3.......	0 30 50	0 33 00	0 35 10	0 37 30
1.4.......	0 28 40	0 30 40	0 32 40	0 34 50
1.5.......	0 26 40	0 28 40	0 30 30	0 32 30
1.6.......	0 25 00	0 26 50	0 28 40	0 30 30
1.7.......	0 23 40	0 25 20	0 28 00	0 28 40
1.8.......	0 22 20	0 23 50	0 25 30	0 27 00
1.9.......	0 21 10	0 22 40	0 24 10	0 25 40
2.0.......	0 20 00	0 21 30	0 22 50	0 24 20

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	70 Feet.	75 Feet.	80 Feet.	85 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 19 10	0 20 30	0 21 50	0 23 10
2.2.......	0 18 10	0 19 30	0 20 50	0 22 10
2.3.......	0 17 30	0 18 40	0 20 00	0 21 10
2.4.......	0 16 40	0 17 50	0 19 10	0 20 20
2.5.......	0 16 00	0 17 10	0 18 20	0 19 30
2.6.......	0 15 20	0 16 30	0 17 40	0 18 40
2.7.......	0 14 50	0 15 50	0 17 00	0 18 00
2.8.......	0 14 20	0 15 20	0 16 20	0 17 20
2.9.......	0 13 50	0 14 50	0 15 50	0 16 50
3.0.......	0 13 20	0 14 20	0 15 20	0 16 10
3.1.......	0 13 00	0 14 00	0 14 50	0 15 40
3.2.......	0 12 30	0 13 30	0 14 20	0 15 10
3.3.......	0 12 10	0 13 00	0 13 50	0 14 50
3.4.......	0 11 50	0 12 40	0 13 30	0 14 20
3.5.......	0 11 30	0 12 20	0 13 10	0 13 50
3.6.......	0 11 10	0 12 00	0 12 40	0 13 20
3.7.......	0 10 50	0 11 40	0 12 20	0 13 10
3.8.......	0 10 30	0 11 20	0 12 00	0 12 50
3.9.......	0 10 20	0 11 00	0 11 40	0 12 30
4.0.......	0 10 00	0 10 40	0 11 30	0 12 10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	90 Feet.	95 Feet.	100 Feet.	105 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	8 31 50	8 59 50	9 27 40	9 55 30
0.2.......	4 17 20	4 31 30	4 45 50	5 00 00
0.3.......	2 51 40	3 01 20	3 10 50	3 20 20
0.4.......	2 08 50	2 25 00	2 23 10	2 30 20
0.5.......	1 43 10	1 48 50	1 54 30	2 00 20
0.6... ...	1 26 00	1 30 40	1 35 30	1 40 10
0.7.......	1 13 40	1 17 40	1 21 50	1 26 00
0.8.......	1 04 30	1 08 00	1 11 40	1 15 10
0.9.......	0 57 20	1 00 30	1 03 40	1 06 50
1.0.......	0 51 30	0 54 30	0 57 20	1 00 10
1.1.......	0 46 50	0 49 30	0 52 00	0 54 40
1.2.......	0 43 00	0 45 20	0 47 40	0 50 10
1.3.......	0 39 40	0 41 50	0 44 00	0 46 20
1.4.......	0 36 50	0 38 50	0 40 50	0 43 00
1.5.......	0 34 20	0 36 20	0 38 10	0 40 10
1.6.......	0 32 10	0 34 00	0 35 50	0 37 40
1.7.......	0 30 20	0 32 00	0 33 40	0 35 20
1.8.......	0 28 40	0 30 10	0 31 50	0 33 20
1.9.......	0 27 10	0 28 40	0 30 10	0 31 40
2.0.......	0 25 50	0 27 10	0 28 40	0 30 00

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	90 Feet.	95 Feet.	100 Feet.	105 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 24 30	0 25 50	0 27 20	0 28 40
2.2.......	0 23 30	0 24 40	0 26 00	0 27 20
2.3.......	0 22 20	0 23 40	0 24 50	0 26 10
2.4.......	0 21 30	0 22 40	0 23 50	0 25 00
2.5.......	0 20 40	0 21 50	0 22 50	0 24 00
2.6.......	0 19 50	0 21 00	0 22 00	0 23 10
2.7.......	0 19 10	0 20 10	0 21 10	0 22 20
2.8.......	0 18 20	0 19 30	0 20 30	0 21 30
2.9.......	0 17 50	0 18 50	0 19 40	0 20 40
3.0.......	0 17 10	0 18 10	0 19 10	0 20 00
3.1.......	0 16 40	0 17 30	0 18 30	0 19 20
3.2.......	0 16 10	0 17 00	0 17 50	0 18 50
3.3.......	0 15 40	0 16 30	0 17 20	0 18 10
3.4.......	0 15 10	0 16 00	0 16 50	0 17 40
3.5.......	0 14 40	0 15 30	0 16 20	0 17 10
3.6.......	0 14 20	0 15 10	0 15 50	0 16 40
3.7.......	0 14 00	0 14 40	0 15 30	0 16 10
3.8.......	0 13 30	0 14 20	0 15 00	0 15 50
3.9.......	0 13 10	0 14 00	0 14 40	0 15 20
4.0.......	0 12 50	0 13 40	0 14 20	0 15 00

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	110 Feet.			115 Feet.			120 Feet.			125 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1.......	10	23	20	10	51	00	11	18	40	11	46	10
0.2.......	5	14	10	5	28	30	5	42	40	5	56	50
0.3.......	3	29	50	3	39	20	3	48	50	3	58	20
0.4.......	2	37	30	2	44	40	2	51	40	2	58	50
0.5.......	2	06	00	2	11	40	2	17	30	2	23	10
0.6.......	1	45	00	1	49	50	1	54	30	1	59	20
0.7.......	1	30	00	1	34	10	1	38	10	1	42	20
0.8.......	1	18	50	1	22	20	1	26	00	1	29	30
0.9.......	1	10	00	1	13	10	1	16	20	1	19	30
1.0.......	1	03	00	1	05	50	1	08	40	1	11	40
1.1.......	0	57	20	0	59	50	1	02	30	1	05	10
1.2.......	0	52	30	0	54	50	0	57	20	0	59	40
1.3.......	0	48	30	0	50	40	0	52	50	0	55	00
1.4.......	0	45	00	0	47	00	0	49	10	0	51	10
1.5.......	0	42	00	0	44	00	0	45	50	0	47	40
1.6.......	0	39	20	0	41	10	0	43	00	0	44	50
1.7.......	0	37	00	0	38	50	0	40	30	0	42	10
1.8.......	0	35	00	0	36	40	0	38	10	0	39	50
1.9.......	0	33	10	0	34	40	0	36	10	0	37	40
2.0.......	0	31	30	0	33	00	0	34	20	0	35	50

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	110 Feet.	115 Feet.	120 Feet.	125 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 30 00	0 31 20	0 32 40	0 34 10
2.2.......	0 28 40	0 30 00	0 31 10	0 32 30
2.3.......	0 27 20	0 28 40	0 29 50	0 31 10
2.4.......	0 26 20	0 27 30	0 28 40	0 29 50
2.5.......	0 25 10	0 26 20	0 27 30	0 28 40
2.6.......	0 24 10	0 25 20	0 26 30	0 27 30
2.7.......	0 23 20	0 24 20	0 25 30	0 26 30
2.8.......	0 22 30	0 23 30	0 24 30	0 25 30
2.9.......	0 21 40	0 22 40	0 23 40	0 24 40
3.0.......	0 21 00	0 22 00	0 22 50	0 23 50
3.1.......	0 20 20	0 21 10	0 22 10	0 23 10
3.2.......	0 19 40	0 20 30	0 21 30	0 22 20
3.3.......	0 19 10	0 20 00	0 20 50	0 21 40
3.4.......	0 18 30	0 19 20	0 20 10	0 21 00
3.5.......	0 18 00	0 18 50	0 19 40	0 20 30
3.6.......	0 17 30	0 18 20	0 19 10	0 19 50
3.7.......	0 17 00	0 17 50	0 18 30	0 19 20
3.8.......	0 16 30	0 17 20	0 18 10	0 18 50
3.9.......	0 16 10	0 16 50	0 17 40	0 18 20
4.0.......	0 15 40	0 16 30	0 17 10	0 17 50

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	130 Feet.			135 Feet.			140 Feet.			145 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1	12	13	30	12	40	50	13	08	00	13	35	10
0.2	6	11	00	6	25	10	6	39	20	6	53	20
0.3	4	07	50	4	17	20	4	26	50	4	36	20
0.4	3	06	00	3	13	10	3	20	20	3	27	30
0.5	2	28	50	2	34	40	2	40	20	2	46	00
0.6	2	04	00	2	08	50	2	13	40	2	18	20
0.7	1	46	20	1	50	30	1	54	30	1	58	40
0.8	1	33	00	1	36	40	1	40	10	1	43	50
0.9	1	22	40	1	26	00	1	29	10	1	32	20
1.0	1	14	30	1	17	20	1	20	10	1	23	00
1.1	1	07	40	1	10	20	1	12	50	1	15	30
1.2	1	02	00	1	04	30	1	06	50	1	09	10
1.3	0	57	20	0	59	30	1	01	40	1	03	50
1.4	0	53	10	0	55	10	0	57	20	0	59	20
1.5	0	49	40	0	51	30	0	53	30	0	55	20
1.6	0	46	30	0	48	20	0	50	10	0	51	50
1.7	0	43	50	0	45	30	0	47	10	0	48	50
1.8	0	41	20	0	43	00	0	44	30	0	46	10
1.9	0	39	10	0	40	40	0	42	10	0	43	40
2.0	0	37	10	0	38	40	0	40	10	0	41	30

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	130 Feet.	135 Feet.	140 Feet.	145 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 35 30	0 36 50	0 38 10	0 39 30
2.2.......	0 33 50	0 35 10	0 36 30	0 37 50
2.3.......	0 32 20	0 33 40	0 34 50	0 36 10
2.4.......	0 31 00	0 32 10	0 33 20	0 34 40
2.5.......	0 29 50	0 31 00	0 32 00	0 33 10
2.6.......	0 28 40	0 29 40	0 30 50	0 32 00
2.7.......	0 27 30	0 28 40	0 29 40	0 30 50
2.8.......	0 26 40	0 27 40	0 28 40	0 29 40
2.9.......	0 25 40	0 26 40	0 27 40	0 28 40
3.0.......	0 24 50	0 25 50	0 26 50	0 27 40
3.1.......	0 24 00	0 25 00	0 25 50	0 26 50
3.2.......	0 23 20	0 24 10	0 25 00	0 26 00
3.3.......	0 22 30	0 23 30	0 24 20	0 25 10
3.4.......	0 21 50	0 22 40	0 23 30	0 24 30
3.5.......	0 21 20	0 22 10	0 22 50	0 23 40
3.6.......	0 20 40	0 21 30	0 22 20	0 23 00
3.7.......	0 20 10	0 20 50	0 21 40	0 22 30
3.8.......	0 19 40	0 20 20	0 21 10	0 21 50
3.9.......	0 19 10	0 19 50	0 20 30	0 21 20
4.0.......	0 18 40	0 19 20	0 20 00	0 20 50

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	150 Feet.			155 Feet.			160 Feet.			165 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1.......	14	02	10	14	29	00	14	55	50	15	22	30
0.2.......	7	07	30	7	21	40	7	35	40	7	49	40
0.3.......	4	45	50	4	55	20	5	04	50	5	14	10
0.4.......	3	34	30	3	41	40	3	48	50	3	56	00
0.5.......	2	51	40	2	57	30	3	03	10	3	08	50
0.6.......	2	23	10	2	27	50	2	32	40	2	37	30
0.7.......	2	02	40	2	06	50	2	10	50	2	15	00
0.8.......	1	47	20	1	51	00	1	54	30	1	58	10
0.9.......	1	35	30	1	38	40	1	41	50	1	45	00
1.0.......	1	26	00	1	28	50	1	31	40	1	34	30
1.1.......	1	18	10	1	20	49	1	23	20	1	26	00
1.2.......	1	11	40	1	14	00	1	16	20	1	18	50
1.3.......	1	06	10	1	08	20	1	10	30	1	12	40
1.4.......	1	01	20	1	03	30	1	05	30	1	07	30
1.5.......	0	57	20	0	59	10	1	01	10	1	03	00
1.6.......	0	53	40	0	55	30	0	57	20	0	59	00
1.7.......	0	50	30	0	52	10	0	53	50	0	55	40
1.8.......	0	47	40	0	49	20	0	51	00	0	52	30
1.9.......	0	45	10	0	46	40	0	48	10	0	49	40
2.0.......	0	43	00	0	44	20	0	45	50	0	47	20

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	150 Feet.	155 Feet.	160 Feet.	165 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 40 50	0 42 20	0 43 40	0 45 00
2.2.......	0 39 00	0 40 20	0 41 40	0 43 00
2.3.......	0 37 20	0 38 40	0 39 50	0 41 10
2.4.......	0 35 50	0 37 00	0 38 10	0 39 20
2.5.......	0 34 20	0 35 30	0 36 40	0 37 50
2.6.......	0 33 00	0 34 10	0 35 20	0 36 20
2.7.......	0 31 50	0 32 50	0 34 00	0 35 00
2.8.......	0 30 40	0 31 40	0 32 40	0 33 50
2.9.......	0 29 40	0 30 40	0 31 40	0 32 40
3.0.......	0 28 40	0 29 40	0 30 30	0 31 30
3.1.......	0 27 40	0 28 40	0 29 30	0 30 30
3.2.......	0 26 50	0 27 40	0 28 40	0 29 30
3.3.......	0 26 00	0 26 50	0 27 50	0 28 40
3.4.......	0 25 20	0 26 10	0 27 00	0 27 50
3.5.......	0 24 30	0 25 20	0 26 10	0 27 00
3.6.......	0 23 50	0 24 40	0 25 30	0 26 20
3.7.......	0 23 10	0 24 00	0 24 50	0 25 30
3.8.......	0 22 40	0 23 20	0 24 10	0 24 50
3.9.......	0 22 00	0 22 50	0 23 30	0 24 10
4.0.......	0 21 30	0 22 10	0 22 50	0 23 40

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	170 Feet.			175 Feet.			180 Feet.			185 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1.......	15	49	10	16	15	40	16	42	00	17	08	10
0.2.......	8	03	50	8	17	50	8	31	50	8	45	50
0.3.......	5	23	40	5	33	10	5	42	40	5	52	00
0.4.......	4	03	10	4	10	10	4	17	20	4	24	30
0.5.......	3	14	40	3	20	20	3	26	00	3	31	40
0.6.......	2	42	10	2	47	00	2	51	40	2	56	30
0.7.......	2	19	00	2	23	10	2	27	10	2	31	20
0.8.......	2	01	40	2	05	20	2	08	50	2	12	30
0.9.......	1	48	10	1	51	20	1	54	30	1	57	40
1.0.......	1	37	20	1	40	10	1	43	10	1	46	00
1.1.......	1	28	30	1	31	10	1	33	40	1	36	20
1.2.......	1	21	10	1	23	30	1	26	00	1	28	20
1.3.......	1	14	50	1	17	10	1	19	20	1	21	30
1.4.......	1	09	30	1	11	40	1	13	40	1	15	40
1.5.......	1	05	00	1	06	50	1	08	40	1	10	40
1.6.......	1	00	50	1	02	40	1	04	30	1	06	10
1.7.......	0	57	20	0	59	00	1	00	40	1	02	20
1.8.......	0	54	10	0	55	40	0	57	20	0	58	50
1.9.......	0	51	20	0	52	50	0	54	20	0	55	50
2.0.......	0	48	40	0	50	10	0	51	30	0	53	00

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	170 Feet.	175 Feet.	180 Feet.	185 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 46 20	0 47 40	0 49 10	0 50 30
2.2.......	0 44 20	0 45 30	0 46 50	0 48 10
2.3.......	0 42 20	0 43 40	0 44 50	0 46 00
2.4.......	0 40 30	0 41 50	0 43 00	0 44 10
2.5.......	0 39 00	0 40 10	0 41 10	0 42 20
2.6.......	0 37 30	0 38 30	0 39 40	0 40 50
2.7.......	0 36 00	0 37 10	0 38 10	0 39 10
2.8.......	0 34 50	0 35 50	0 36 50	0 37 50
2.9.......	0 33 30	0 34 30	0 35 30	0 36 30
3.0.......	0 32 30	0 33 20	0 34 20	0 35 20
3.1.......	0 31 20	0 32 20	0 33 20	0 34 10
3.2.......	0 30 30	0 31 20	0 32 10	0 33 10
3.3.......	0 29 30	0 30 20	0 31 10	0 32 10
3.4.......	0 28 40	0 29 30	0 30 20	0 31 10
3.5.......	0 27 50	0 28 40	0 29 30	0 30 20
3.6.......	0 27 00	0 27 50	0 28 40	0 29 30
3.7.......	0 26 20	0 27 10	0 27 50	0 28 40
3.8.......	0 25 40	0 26 20	0 27 10	0 27 50
3.9.......	0 25 00	0 25 40	0 26 30	0 27 10
4.0.......	0 24 20	0 25 00	0 25 50	0 26 30

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	190 Feet.	195 Feet.	200 Feet.	205 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	17 34 20	18 00 10	18 26 10	18 51 50
0.2.......	8 59 50	9 13 50	9 27 40	9 41 40
0.3.......	6 01 30	6 11 00	6 20 20	6 29 50
0.4.......	4 31 30	4 38 40	4 45 50	4 53 00
0.5.......	3 37 30	3 43 10	3 48 50	3 54 30
0.6.......	3 01 20	3 06 00	3 10 50	3 15 30
0.7.......	2 35 20	2 39 30	2 43 30	2 47 40
0.8.......	2 16 00	2 19 30	2 23 10	2 26 40
0.9.......	2 00 50	2 04 00	2 07 20	2 10 30
1.0.......	1 48 50	1 51 40	1 45 30	1 57 20
1.1.......	1 39 00	1 41 30	1 44 10	1 46 40
1.2.......	1 30 40	1 33 00	1 35 30	1 37 50
1.3.......	1 23 40	1 26 00	1 28 10	1 30 20
1.4.......	1 17 40	1 19 50	1 21 50	1 23 50
1.5.......	1 12 30	1 14 30	1 16 20	1 18 20
1.6.......	1 08 00	1 09 50	1 11 40	1 13 20
1.7.......	1 04 00	1 05 40	1 07 20	1 09 00
1.8.......	1 00 30	1 02 00	1 03 40	1 05 10
1.9.......	0 57 20	0 58 50	1 00 20	1 01 50
2.0.......	0 54 30	0 55 50	0 57 20	0 58 40

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	190 Feet.	195 Feet.	200 Feet.	205 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 51 50	0 53 10	0 54 30	0 56 00
2.2.......	0 49 30	0 50 50	0 52 00	0 53 20
2.3.......	0 47 20	0 48 30	0 49 50	0 51 00
2.4.......	0 45 20	0 46 30	0 47 40	0 49 00
2.5.......	0 43 30	0 44 40	0 45 50	0 47 00
2.6.......	0 41 50	0 43 00	0 44 00	0 45 10
2.7.......	0 40 20	0 41 20	0 42 30	0 43 30
2.8.......	0 38 50	0 39 50	0 40 50	0 42 00
2.9.......	0 37 30	0 38 30	0 39 30	0 40 30
3.0.......	0 36 20	0 37 10	0 38 10	0 39 10
3.1.......	0 35 10	0 36 00	0 37 00	0 37 50
3.2.......	0 34 00	0 34 50	0 35 50	0 36 40
3.3.......	0 33 00	0 33 50	0 34 40	0 35 40
3.4.......	0 32 00	0 32 50	0 33 40	0 34 30
3.5.......	0 31 10	0 31 50	0 32 40	0 33 30
3.6.......	0 30 10	0 31 00	0 31 50	0 32 40
3.7.......	0 29 20	0 30 10	0 31 00	0 31 40
3.8.......	0 28 40	0 29 20	0 30 10	0 30 50
3.9.......	0 27 50	0 28 40	0 29 20	0 30 10
4.0.......	0 27 10	0 28 00	0 28 40	0 29 20

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	210 Feet.	215 Feet.	220 Feet.	225 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	19 17 20	19 42 50	20 08 10	20 30 20
0.2.......	9 56 00	10 09 30	10 23 20	10 37 10
0.3.......	6 39 20	6 48 40	6 58 10	7 07 30
0.4.......	5 00 00	5 07 10	5 14 10	5 21 20
0.5.......	4 00 10	4 06 00	4 11 40	4 17 20
0.6.......	3 20 20	3 25 00	3 29 50	3 34 30
0.7.......	2 51 40	2 55 50	2 59 50	3 04 00
0.8.......	2 30 20	2 33 50	2 37 30	2 41 00
0.9.......	2 13 40	2 16 50	2 20 00	2 23 10
1.0.......	2 00 20	2 03 10	2 06 00	2 08 50
1.1.......	1 49 20	1 52 00	1 54 30	1 57 10
1.2.......	1 40 10	1 42 40	1 45 00	1 47 20
1.3.......	1 32 30	1 34 40	1 37 00	1 39 10
1.4.......	1 26 00	1 28 00	1 30 00	1 32 00
1.5.......	1 20 10	1 22 10	1 24 00	1 26 00
1.6.......	1 15 10	1 17 00	1 18 50	1 20 30
1.7.......	1 10 50	1 12 30	1 14 10	1 15 50
1.8.......	1 06 50	1 08 30	1 10 00	1 11 40
1.9.......	1 03 20	1 04 50	1 06 20	1 07 50
2.0.......	1 00 10	1 01 30	1 03 00	1 04 30

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	210 Feet.	215 Feet.	220 Feet.	225 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	0 57 20	0 58 40	1 00 00	1 01 20
2.2.......	0 54 40	0 56 00	0 57 20	0 58 40
2.3.......	0 52 20	0 53 30	0 54 50	0 56 00
2.4.......	0 50 10	0 51 20	0 52 30	0 53 40
2.5.......	0 48 10	0 49 20	0 50 20	0 51 30
2.6.......	0 46 20	0 47 20	0 48 30	0 49 30
2.7.......	0 44 30	0 45 40	0 46 40	0 47 40
2.8.......	0 43 00	0 44 00	0 45 00	0 46 00
2.9.......	0 41 30	0 42 30	0 43 30	0 44 30
3.0.......	0 40 10	0 41 00	0 42 00	0 43 00
3.1.......	0 38 50	0 39 40	0 40 40	0 41 40
3.2.......	0 37 40	0 38 30	0 39 20	0 40 20
3.3.......	0 36 30	0 37 20	0 38 10	0 39 00
3.4.......	0 35 20	0 36 10	0 37 00	0 37 50
3.5.......	0 34 20	0 35 10	0 36 00	0 36 50
3.6.......	0 33 20	0 34 10	0 35 00	0 35 50
3.7.......	0 32 30	0 33 20	0 34 00	0 34 50
3.8.......	0 31 40	0 32 20	0 33 10	0 33 50
3.9.......	0 30 50	0 31 30	0 32 20	0 33 00
4.0.......	0 30 00	0 30 50	0 31 30	0 32 10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	230 Feet.	235 Feet.	240 Feet.	245 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
0.1.......	20 58 20	21 23 20	21 48 00	22 12 40
0.2.......	10 51 00	11 04 50	11 18 40	11 32 20
0.3.......	7 16 50	7 26 20	7 35 40	7 45 00
0.4.......	5 28 30	5 35 30	5 42 40	5 49 40
0.5.......	4 23 00	4 28 40	4 34 30	4 40 10
0.6.......	3 39 20	3 44 00	3 48 50	3 53 40
0.7.......	3 08 00	3 12 10	3 16 10	3 20 20
0.8.......	2 44 40	2 48 10	2 51 40	2 55 20
0.9.......	2 26 20	2 29 30	2 32 40	2 35 50
1.0.......	2 11 40	2 14 30	2 17 30	2 20 20
1.1.......	1 59 40	2 02 20	2 05 00	2 07 30
1.2.......	1 49 50	1 52 10	1 54 30	1 57 00
1.3.......	1 41 20	1 43 30	1 45 40	1 48 00
1.4.......	1 34 10	1 36 10	1 38 10	1 40 10
1.5.......	1 27 50	1 29 40	1 31 40	1 33 30
1.6.......	1 22 20	1 24 10	1 26 00	1 27 40
1.7.......	1 17 30	1 19 10	1 20 50	1 22 30
1.8.......	1 13 10	1 14 50	1 16 20	1 18 00
1.9.......	1 09 20	1 10 50	1 12 20	1 13 50
2.0.......	1 05 50	1 07 20	1 08 40	1 10 10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	230 Feet.	235 Feet.	240 Feet.	245 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	1 02 40	1 04 10	1 05 30	1 06 50
2.2.......	0 59 50	1 01 10	1 02 30	1 03 50
2.3.......	0 57 20	0 58 30	0 59 50	1 01 00
2.4.......	0 54 50	0 56 10	0 57 20	0 58 30
2.5.......	0 52 40	0 53 50	0 55 00	0 56 10
2.6.......	0 50 40	0 51 50	0 52 50	0 54 00
2.7.......	0 48 50	0 49 50	0 51 00	0 52 00
2.8.......	0 47 00	0 48 00	0 49 10	0 50 10
2.9.......	0 45 30	0 46 30	0 47 20	0 48 20
3.0.......	0 43 50	0 44 50	0 45 50	0 46 50
3.1.......	0 42 30	0 43 30	0 44 20	0 45 20
3.2.......	0 41 10	0 42 00	0 43 00	0 44 00
3.3.......	0 40 00	0 40 50	0 41 40	0 42 30
3.4.......	0 38 40	0 39 40	0 40 30	0 41 20
3.5.......	0 37 40	0 38 30	0 39 20	0 40 10
3.6.......	0 36 40	0 37 20	0 38 10	0 39 00
3.7.......	0 35 40	0 36 20	0 37 10	0 38 00
3.8.......	0 34 40	0 35 30	0 36 10	0 37 00
3.9.......	0 33 50	0 34 30	0 35 10	0 36 00
4.0.......	0 33 00	0 33 40	0 34 20	0 35 10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	250 Feet.			260 Feet.			270 Feet.			280 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1.......	22	37	10	23	25	40	24	13	40	25	01	00
0.2.......	11	46	10	12	13	30	12	40	50	13	08	00
0.3.......	7	54	30	8	13	10	8	31	50	8	50	30
0.4.......	5	56	50	6	11	00	6	25	10	6	39	20
0.5.......	4	45	50	4	57	10	5	08	30	5	20	00
0.6.......	3	58	20	4	07	50	4	17	20	4	26	50
0.7.......	3	24	20	3	32	30	3	40	40	3	48	50
0.8.......	2	58	50	3	06	00	3	13	10	3	20	20
0.9.......	2	39	00	2	45	20	2	51	40	2	58	10
1.0.......	2	23	10	2	28	50	2	34	40	2	40	20
1.1.......	2	10	10	2	15	20	2	20	30	2	25	40
1.2.......	1	59	20	2	04	10	2	08	50	2	13	40
1.3.......	1	50	10	1	54	30	1	59	00	2	03	20
1.4.......	1	42	20	1	46	20	1	50	30	1	54	30
1.5.......	1	35	30	1	39	20	1	43	10	1	46	50
1.6.......	1	29	30	1	33	00	1	36	40	1	40	10
1.7.......	1	24	10	1	27	40	1	31	00	1	34	20
1.8.......	1	19	30	1	22	40	1	26	00	1	29	10
1.9.......	1	15	20	1	18	20	1	21	20	1	24	30
2.0.......	1	11	40	1	14	30	1	17	20	1	20	10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.			
	250 Feet.	260 Feet.	270 Feet.	280 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	1 08 10	1 11 00	1 13 40	1 16 20
2.2.......	1 05 10	1 07 40	1 10 20	1 12 50
2.3.......	1 02 20	1 04 50	1 07 10	1 09 40
2.4.......	0 59 40	1 02 00	1 04 30	1 06 50
2.5.......	0 57 20	0 59 30	1 01 50	1 04 10
2.6.......	0 55 00	0 57 20	0 59 30	1 01 40
2.7.......	0 53 00	0 55 10	0 57 20	0 59 20
2.8.......	0 51 10	0 53 10	0 55 10	0 57 20
2.9.......	0 49 20	0 51 20	0 53 20	0 55 20
3.0.......	0 47 40	0 49 40	0 51 30	0 53 30
3.1.......	0 46 10	0 48 00	0 49 50	0 51 40
3.2.......	0 44 50	0 46 30	0 48 20	0 50 10
3.3.......	0 43 20	0 45 10	0 46 50	0 48 40
3.4.......	0 42 10	0 43 50	0 45 30	0 47 10
3.5.......	0 40 50	0 42 30	0 44 10	0 45 50
3.6.......	0 39 50	0 41 20	0 43 00	0 44 30
3.7.......	0 38 40	0 40 20	0 41 50	0 43 20
3.8.......	0 37 40	0 39 10	0 40 40	0 42 10
3.9.......	0 36 40	0 38 10	0 39 40	0 41 10
4.0.......	0 35 50	0 37 10	0 38 40	0 40 10

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.											
	290 Feet.			300 Feet.			310 Feet.			320 Feet.		
	°	′	″	°	′	″	°	′	″	°	′	″
0.1........	25	30	00	26	15	50	27	01	00	27	45	30
0.2........	13	24	50	13	51	30	14	18	10	14	44	40
0.3........	9	02	00	9	20	20	9	38	40	9	57	00
0.4........	6	48	00	7	02	00	7	15	50	7	29	40
0.5........	5	27	00	5	38	10	5	49	20	6	00	30
0.6........	4	32	40	4	42	00	4	51	30	5	00	50
0.7........	3	53	50	4	01	50	4	10	00	4	18	00
0.8........	3	24	40	3	31	50	3	38	50	3	45	50
0.9........	3	02	00	3	08	20	3	14	30	3	20	50
1.0........	2	43	50	2	49	30	2	55	10	3	00	50
1.1........	2	29	00	2	34	10	2	39	10	2	44	20
1.2........	2	16	30	2	21	20	2	26	00	2	30	40
1.3........	2	06	00	2	10	20	2	14	50	2	19	10
1.4........	1	57	00	2	01	10	2	05	10	2	09	10
1.5........	1	49	20	1	53	00	1	56	50	2	00	30
1.6........	1	42	30	1	46	00	1	49	30	1	53	00
1.7........	1	36	30	1	39	40	1	43	00	1	46	20
1.8........	1	31	00	1	34	10	1	37	20	1	40	30
1.9........	1	26	20	1	29	10	1	32	10	1	35	10
2.0........	1	22	00	1	24	50	1	27	40	1	30	30

PATTERSON'S DANGER-ANGLE TABLES.

Distance in Miles and Tenths.	Height of Light Above Sea-Level.		
	290 Feet.	300 Feet.	310 Feet.	320 Feet.
	° ′ ″	° ′ ″	° ′ ″	° ′ ″
2.1.......	1 18 00	1 20 50	1 23 30	1 26 10
2.2.......	1 14 30	1 17 00	1 19 40	1 22 10
2.3.......	1 11 20	1 13 40	1 16 10	1 18 40
2.4.......	1 08 20	1 10 40	1 13 00	1 15 20
2.5.......	1 05 30	1 07 50	1 10 10	1 12 20
2.6.......	1 03 00	1 05 10	1 07 20	1 09 30
2.7.......	1 00 40	1 02 50	1 04 50	1 07 00
2.8.......	0 58 30	1 00 30	1 02 40	1 04 40
2.9.......	0 56 30	0 58 30	1 00 30	1 02 20
3.0.......	0 54 40	0 56 30	0 58 20	1 00 20
3.1.......	0 52 50	0 54 40	0 56 30	0 58 20
3.2.......	0 51 10	0 53 00	0 54 50	0 56 30
3.3.......	0 49 40	0 51 20	0 53 10	0 54 50
3.4.......	0 48 10	0 49 50	0 51 30	0 53 10
3.5.......	0 46 50	0 48 30	0 50 00	0 51 40
3.6.......	0 45 30	0 47 10	0 48 40	0 50 10
3.7.......	0 44 20	0 45 50	0 47 20	0 48 50
3.8.......	0 43 10	0 44 40	0 46 10	0 47 40
3.9.......	0 42 00	0 43 30	0 45 00	0 46 20
4.0.......	0 41 00	0 42 20	0 43 50	0 45 10

PATTERSON'S STAR TABLES.

Name of Star.	Declination.	Magnitude.	Jan. 1.	Feb. 1.	Mar. 1.	April 1.	May 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Oct. 1.	Nov. 1.	Dec. 1.
	Astronomical Apparent Time of Crossing the Meridian of the Ship.													
	°		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
α Aurigæ (Capella)..	46 N.	1	10 20	8 07	6 18	4 25	2 34	0 31	22 26	20 22	18 26	16 38	14 41	12 37
α Lyræ (Vega)......	39 N.	1	23 44	21 31	19 42	17 49	15 58	13 55	11 50	9 46	7 50	6 02	4 05	2 01
β Geminor'm (Pol'x).	28 N.	1	12 50	10 37	8 48	6 55	5 04	3 01	0 56	22 52	20 56	19 08	17 11	15 07
α Bootis (Arcturus)..	20 N.	1	19 22	17 09	15 20	13 27	11 36	9 33	7 28	5 24	3 28	1 40	23 43	21 39
α Tauri (Aldebaran).	16 N.	1	9 41	7 28	5 39	3 46	1 55	23 52	21 47	19 43	17 47	15 59	14 02	11 58
α Leonis (Regulus)..	12 N.	1	15 14	13 01	11 12	9 19	7 28	5 25	3 20	1 16	23 20	21 32	19 35	17 31
α Aquilæ (Altair) ...	9 N.	1	0 57	22 44	20 55	19 02	17 11	15 08	13 03	10 59	9 03	7 15	5 18	3 14
α Orionis...........	7 N.	1	11 00	8 47	6 58	5 05	3 14	1 11	23 06	21 02	19 06	17 18	15 21	13 17
α Can. Min. (Proc'n).	5 N.	1	12 45	10 32	8 43	6 50	4 59	2 56	0 51	22 47	20 51	19 03	17 06	15 02
β Orionis (Rigel)....	8 S.	1	10 20	8 07	6 18	4 25	2 34	0 31	22 26	20 22	18 26	16 38	14 41	12 37
α Virginis (Spica)..	11 S.	1	18 31	16 18	14 29	12 36	10 45	8 42	6 37	4 33	2 37	0 49	22 52	20 48
α Canis Maj. (Sirius).	17 S.	1	11 51	9 38	7 49	5 56	4 05	2 02	23 57	21 53	19 57	18 09	16 12	14 08
α Scorpii (Antares)..	26 S.	1	21 34	19 21	17 32	15 39	13 48	11 45	9 40	7 36	5 40	3 52	1 55	23 51
α Pis. Aust. (Fomal.).	30 S.	1	4 03	1 50	0 01	22 08	20 17	18 14	16 09	14 05	12 09	10 21	8 24	6 20
α Argus (Canopus)..	53 S.	1	11 33	9 20	7 31	5 38	3 47	1 44	23 39	21 35	19 39	17 51	15 54	13 50
α Eridini (Achern'r).	58 S.	1	6 45	4 32	2 43	0 50	22 59	20 56	18 51	16 47	14 51	13 03	11 06	9 02
β Centauri.	60 S.	1	19 07	16 54	15 05	13 12	11 21	9 18	7 13	5 09	3 13	1 25	23 28	21 24
α Centauri..........	60 S.	1	19 43	17 30	15 41	13 48	11 57	9 54	7 49	5 45	3 49	2 01	0 04	22 00
α Crucis............	63 S.	1	17 32	15 19	13 30	11 37	9 46	7 43	5 38	3 34	1 38	23 50	21 53	19 49

PATTERSON'S STAR TABLES.

Astronomical Apparent Time of Crossing the Meridian of the Ship.

Name of Star.	Declination.	Magnitude.	Jan. 1.	Feb. 1.	Mar. 1.	April 1.	May 1.	June 1.	July 1.	Aug. 1.	Sept. 1.	Oct. 1.	Nov. 1.	Dec. 1.
	°		h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.	h. m.
α Ceti..............	4 N.	2	8 08	5 55	4 06	2 13	0 22	22 19	20 14	18 10	16 14	14 26	12 29	10 25
γ Pegasi (Algenib)...	15 N.	3	5 19	3 06	1 17	23 24	21 33	19 30	17 25	15 21	13 25	11 37	9 40	7 36
α Pegasi (Markab)...	15 N.	2	4 10	1 57	0 08	22 15	20 24	18 21	16 16	14 12	12 16	10 28	8 31	6 27
α Arietis...........	23 N.	2	7 12	4 59	3 10	1 17	23 26	21 23	19 18	17 14	15 18	13 30	11 33	9 29
α ²Geminorum (Cas.)	32 N.	2	12 39	10 26	8 37	6 44	4 53	2 50	0 45	22 41	20 45	18 57	17 00	14 56
β Andromedæ.......	35 N.	2	6 15	4 02	2 13	0 20	22 29	20 26	18 21	16 17	14 21	12 33	10 36	8 32
α Persei....	49 N.	2	8 28	6 15	4 26	2 33	0 42	22 39	20 34	18 30	16 34	14 46	12 49	10 45
γ Draconis..........	51 N.	2	23 05	20 52	19 03	17 10	15 19	13 16	11 11	9 07	7 11	5 23	3 26	1 22
γ Ursæ Majoris......	54 N.	2	16 59	14 46	12 57	11 04	9 13	7 10	5 05	3 01	1 05	23 17	21 20	19 16
α Cassiopeæ.........	56 N.	2	5 45	3 32	1 43	23 50	21 59	19 56	17 51	15 47	13 51	12 03	10 06	8 02
α Ursæ Majoris......	62 N.	2	16 08	13 55	12 06	10 13	8 22	6 19	4 14	2 10	0 14	22 26	20 29	18 25
α Draconis	65 N.	3	19 12	16 59	15 10	13 17	11 26	9 23	7 18	5 14	3 18	1 30	23 33	21 29
α Ursæ Min.(Polaris)	89 N.	2	6 31	4 18	2 29	0 36	22 45	20 42	18 37	16 33	14 37	12 49	10 52	8 48
α Aquarii...........	1 S.	3	3 11	0 58	23 09	21 16	19 25	17 22	15 17	13 13	11 17	9 29	7 32	5 28
ε Orionis............	1 S.	2	10 42	8 29	6 40	4 47	2 56	0 53	22 48	20 44	18 48	17 00	15 03	12 59
α Hydræ............	8 S.	2	14 33	12 20	10 31	8 38	6 47	4 44	2 39	0 35	22 39	20 51	18 54	16 50
α Columbæ	34 S.	2	10 47	8 34	6 45	4 52	3 01	0 58	22 53	20 49	18 53	17 05	15 08	13 04
α Gruis.............	47 S.	2	3 12	0 59	23 10	21 17	19 26	17 23	15 18	13 14	11 18	9 30	7 33	5 29
α Pavonis...........	57 S.	2	1 28	23 15	21 26	19 33	17 42	15 39	13 34	11 30	9 34	7 46	5 49	3 45

TABLE OF DISTANCES

AT WHICH OBJECTS CAN BE SEEN AT SEA, ACCORDING TO THEIR RESPECTIVE ELEVATIONS AND THE HEIGHT OF THE OBSERVER'S EYE ABOVE SEA-LEVEL.

Height in Feet.	Distance in Nautical Miles.	Height in Feet.	Distance in Nautical Miles.	Height in Feet.	Distance in Nautical Miles.	Height in Feet.	Distance in Nautical Miles.
5	2.565	55	8.509	110	12.030	450	24.330
10	3.628	60	8.886	120	12.560	500	25.650
15	4.443	65	9.249	130	13 080	550	26.900
20	5.130	70	9.598	140	13.570	600	28.100
25	5 736	75	9.935	150	14.050	650	29.250
30	6.283	80	10.260	200	16.220	700	30.280
35	6.787	85	10.570	250	18.140	800	32.450
40	7.255	90	10.880	300	19.870	900	34.540
45	7.696	95	11.180	350	21 460	1,000	36.280
50	8.112	100	11 470	400	22.940	*	*

Rule.—Add together the figures given for the height of eye above the sea-level and the figures given for the elevation of the object, and the answer will be the distance of the vessel from the object in question.

When a low-lying island, or shore, or the hull of a low-sided vessel is seen awash with the horizon, the distance of the horizon for the height of the observer's eye above the sea-level will alone give the distance from the object.

Example.—The top of a lighthouse 150 feet high is seen awash when the observer's eye is 15 feet above the sea-level—required the distance of the observer from the light ?

Height of eye, 15 feet = 4,443 miles.
Height of light, 150 feet = 14,050 miles.

Distance of observer from light, 18,493 = 18½ miles nearly.

TABLE 27.

To reduce the numbers of Table 26 to other giv

S	0m	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	S
	Time from noon.													
0	0.0	1.0	4.0	9.0	16.0	25.0	36.0	49.0	64.0	81.0	100.0	121.0	144.0	0
1	0.0	1.0	4.1	9.1	16.1	25.2	36.2	49.2	64.3	81.3	100.3	121.4	144.4	1
2	0.0	1.1	4.1	9.2	16.3	25.3	36.4	49.5	64.5	81.6	100.7	121.7	144.8	2
3	0.0	1.1	4.2	9.3	16.4	25.5	36.6	49.7	64.8	81.9	101.0	122.1	145.2	3
4	0.0	1.1	4.3	9.4	16.5	25.7	36.8	49.9	65.1	82.2	101.3	122.5	145.6	4
5	0.0	1.2	4.3	9.5	16.7	25.8	37.0	50.2	65.3	82.5	101.7	122.9	146.0	5
6	0.0	1.2	4.4	9.6	16.8	26.0	37.2	50.4	65.6	82.8	102.0	123.3	146.4	6
7	0.0	1.2	4.5	9.7	16.9	26.2	37.4	50.6	65.9	83.1	102.3	123.6	146.8	7
8	0.0	1.3	4.6	9.8	17.1	26.4	37.6	50.9	66.1	83.4	102.7	124.6	147.2	8
9	0.0	1.3	4.6	9.9	17.2	26.5	37.8	51.1	66.4	83.7	103.0	124.3	147.6	9
10	0.0	1.4	4.7	10.0	17.4	26.7	38.0	51.4	66.7	84.0	103.4	124.7	148.0	10
11	0.0	1.4	4.8	10.1	17.5	26.9	38.2	51.6	67.0	84.3	103.7	125.1	148.4	11
12	0.0	1.4	4.8	10.2	17.6	27.0	38.4	51.8	67.2	84.6	104.0	125.4	148.8	12
13	0.0	1.5	4.9	10.3	17.8	27.2	38.6	52.1	67.5	84.9	104.4	125.8	149.2	13
14	0.1	1.5	5.0	10.5	17.9	27.4	38.9	52.3	67.8	85.3	104.7	126.2	149.7	14
15	0.1	1.6	5.1	10.6	18.1	27.6	39.1	52.6	68.1	85.6	105.1	126.6	150.1	15
16	0.1	1.6	5.1	10.7	18.2	27.7	39.3	52.8	68.3	85.9	105.4	126.9	150.5	16
17	0.1	1.6	5.2	10.8	18.3	27.9	39.5	53.0	68.6	86.2	105.7	127.3	150.9	17
18	0.1	1.7	5.3	10.9	18.5	28.1	39.7	53.3	68.8	86.5	106.1	127.7	151.3	18
19	0.1	1.7	5.4	11.0	18.6	28.3	39.9	53.5	69.2	86.8	106.4	128.1	151.7	19
20	0.1	1.8	5.4	11.1	18.8	28.4	40.1	53.8	69.4	87.1	106.8	128.4	152.1	20
21	0.1	1.8	5.5	11.2	18.9	28.6	40.3	54.0	69.7	87.4	107.1	128.8	152.5	21
22	0.1	1.9	5.6	11.3	19.1	28.8	40.5	54.3	70.0	87.7	107.5	129.2	152.9	22
23	0.1	1.9	5.7	11.4	19.2	29.0	40.7	54.5	70.3	88.0	107.8	129.6	153.3	23
24	0.2	2.0	5.8	11.6	19.4	29.2	41.0	54.8	70.6	88.4	108.2	130.0	153.8	24
25	0.2	2.0	5.8	11.7	19.5	29.3	41.2	55.0	70.8	88.7	108.5	130.3	154.2	25
26	0.2	2.1	5.9	11.8	19.7	29.5	41.4	55.3	71.1	89.0	108.9	130.7	154.6	26
27	0.2	2.1	6.0	11.9	19.8	29.7	41.6	55.5	71.4	89.3	109.2	131.1	155.0	27
28	0.2	2.2	6.1	12.0	20.0	29.9	41.8	55.8	71.7	89.6	109.6	131.5	155.4	28
29	0.2	2.2	6.2	12.1	20.1	30.1	42.0	56.0	72.0	89.9	109.9	131.9	155.8	29
30	0.2	2.2	6.2	12.2	20.2	30.2	42.2	56.2	72.2	90.2	110.2	132.2	156.2	30
31	0.3	2.3	6.3	12.4	20.4	30.4	42.5	56.5	72.5	90.6	110.6	132.6	156.7	31
32	0.3	2.4	6.4	12.5	20.6	30.6	42.7	56.8	72.8	90.9	111.0	133.0	157.1	32
33	0.3	2.4	6.5	12.6	20.7	30.8	42.9	57.0	73.1	91.2	111.3	133.4	157.5	33
34	0.3	2.5	6.6	12.7	20.9	31.0	43.1	57.3	73.4	91.5	111.7	133.8	157.9	34
35	0.3	2.5	6.7	12.8	21.0	31.2	43.3	57.5	73.7	91.8	112.0	134.2	158.3	35
36	0.4	2.6	6.8	13.0	21.2	31.4	43.6	57.8	74.0	92.2	112.4	134.6	158.8	36
37	0.4	2.6	6.8	13.1	21.3	31.5	43.8	58.0	74.3	92.5	112.7	134.9	159.2	37
38	0.4	2.7	6.9	13.2	21.5	31.7	44.0	58.3	74.5	92.8	113.1	135.3	159.6	38
39	0.4	2.7	7.0	13.3	21.6	31.9	44.2	58.5	74.8	93.1	113.4	135.7	160.0	39
40	0.4	2.8	7.1	13.4	21.8	32.1	44.4	58.8	75.1	93.4	113.8	136.1	160.4	40
41	0.5	2.8	7.2	13.6	21.9	32.3	44.7	59.0	75.4	93.8	114.1	136.5	160.9	41
42	0.5	2.9	7.3	13.7	22.1	32.5	44.9	59.3	75.7	94.1	114.5	136.9	161.3	42
43	0.5	2.9	7.4	13.8	22.2	32.7	45.1	59.5	76.0	94.4	114.8	137.3	161.7	43
44	0.5	3.0	7.5	13.9	22.4	32.9	45.3	59.8	76.3	94.7	115.2	137.7	162.1	44
45	0.6	3.1	7.6	14.1	22.6	33.1	45.6	60.1	76.6	95.1	115.6	138.1	162.6	45
46	0.6	3.1	7.7	14.2	22.7	33.3	45.8	60.3	76.9	95.4	115.9	138.5	163.0	46
47	0.6	3.2	7.7	14.3	22.9	33.4	46.0	60.6	77.1	95.7	116.3	138.8	163.4	47
48	0.6	3.2	7.8	14.4	23.0	33.6	46.2	60.8	77.4	96.0	116.6	139.2	163.8	48
49	0.7	3.3	7.9	14.6	23.2	33.8	46.5	61.1	77.7	96.4	117.0	139.6	164.3	49
50	0.7	3.4	8.0	14.7	23.4	34.0	46.7	61.4	78.0	96.7	117.4	140.0	164.7	50
51	0.7	3.4	8.1	14.8	23.5	34.2	46.9	61.6	78.3	97.0	117.7	140.4	165.1	51
52	0.8	3.5	8.2	15.0	23.7	34.4	47.2	61.9	78.6	97.4	118.1	140.8	165.6	52
53	0.8	3.5	8.3	15.1	23.8	34.6	47.4	62.1	78.9	97.7	118.4	141.2	166.0	53
54	0.8	3.6	8.4	15.2	24.0	34.8	47.6	62.4	79.2	98.0	118.8	141.6	166.4	54
55	0.8	3.7	8.5	15.3	24.2	35.0	47.8	62.7	79.5	98.3	119.2	142.0	166.8	55
56	0.9	3.7	8.6	15.5	24.3	35.2	48.1	62.9	79.8	98.7	119.5	142.4	167.3	56
57	0.9	3.8	8.7	15.6	24.5	35.4	48.3	63.2	80.1	99.0	119.9	142.8	167.7	57
58	0.9	3.9	8.8	15.7	24.7	35.6	48.5	63.5	80.4	99.3	120.3	143.2	168.1	58
59	1.0	3.9	8.9	15.9	24.8	35.8	48.8	63.7	80.7	99.7	120.6	143.6	168.6	59
	0m	1m	2m	3m	4m	5m	6m	7m	8m	9m	10m	11m	12m	